WOOD PATTERNMAKING

HERBERT J. McCASLIN

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Wood Patternmaking

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WOOD PATTERNMAKING

A Textbook

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1946

BY

HERBERT J. McCASLIN

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McGRAW-HILL BOOK COMPANY, Inc.

NEW YORK AND LONDON

WOOD PATTERNMAKING

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THE MAPLE PRESS COMPANY, YORK, PA.

PREFACE TO THE FOURTH EDITION

Again the revision of "Wood Patternmaking" has presented an opportunity further to enlarge the text so that it will give greater reality and motivation to the work and present a wider range of present-day shop practice. It also provides a high degree of teaching effectiveness and supplements information that the student may acquire by observation.

As in earlier editions the text is divided into two parts, but it now embodies 64 pattern lessons and 410 illustrations.

Foremost among the new pattern problems are to be found typical examples of match and follow board work, application of the cap-core, skeletonized pattern construction, core-frame setups for molds to be assembled from dry-sand core bodies, core-box and mold arrangement for the casting of interlocking members, the efficient use of machine tools, and the inspection, checking, and recording of patterns. The glossary of pattern-making and molding terms has been expanded.

The text is intended to supply adequate teaching material for a period of six semesters, but the arrangement of the lessons is such that a selection for a shorter course may be readily made.

"Wood Patternmaking" will be found a valuable aid in teaching the reading of drawings and blueprints through the graphical presentation of the separated members of the pattern problems in their perspective relation to that of the drawing of the desired casting.

HERBERT J. MCCASLIN.

PREFACE TO THE FIRST EDITION

This book is for the student who desires to follow the occupation of patternmaking or who wishes to familiarize himself with the principles of the art. The text is based upon a series of problems which have been arranged in a progressive yet flexible manner, and which in the aggregate will constitute (within a certain range) a course in patternmaking and a desirable preparation for more advanced work.

Problems have been selected or designed according to the principles of molding involved and to the difficulties encountered in the construction of the pattern.

Very definite instructions are given pertaining to the order of operations required for the completion of these patterns. Repetition of instructions appearing in the text may seem unnecessary, but the experiences of twelve years as an instructor in patternmaking have convinced the author that too much emphasis cannot be placed upon certain features.

It is not the intention of this book to deal with production methods as applied to patterns. The author is familiar with molding-machine practices and their application to production work, and it is realized that if castings were desired in large numbers, many of the patterns required by the lessons would not be made as described.

The author's intention, however, is to follow those principles of molding and pattern construction which have been established as good practice when a limited number of castings is required and the castings are to be made as individual molds.

The author wishes to acknowledge his appreciation and thanks to his fellow teachers, Carlos H. Handforth and Jay I. Henshaw, for their valuable aid. He also wishes to thank Frank E. Mathewson, Director of the Technical and Industrial

Department of the William L. Dickinson High School, for suggestions and advice incident to the publication of this book. Grateful acknowledgment is made to the American Wood Working Machinery Co., The Porter Cable Co., and The Oliver Machinery Co. for assistance.

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TO THE STUDENT

Patternmaking.—Of the various crafts comprising the metal trades, patternmaking is one of the most important but is perhaps the least understood by the average person. The making of patterns dates back to the time when implements of use were first made by pouring metal as a liquid into a mold. This branch of engineering plays a very important part in the manufacturing of machinery—a feature not often recognized because the product, *patterns*, is used only as a means toward an end in the making of metal castings.

What is meant by a casting? It is the result of a process whereby the metal is reduced, through the action of heat, to a liquid state and poured into molds, usually made of sand, where it is allowed to cool. Later, when removed from the mold, it will be found to have taken the shape that had been planned by the designer and the patternmaker. It will, therefore, be seen that the use of patterns in some form is necessary wherever castings are made by the *sand-molding process*. Castings vary in weight from a few ounces to 200 tons or more. They are made in many forms and of many metals.

Patternmaking is one of the few trades that have not felt the invasion of laborsaving devices. In fact, it has been greatly benefited by new developments that have produced a demand for more intricate castings. It is a clean, interesting occupation that offers a great variety of problems, thereby exercising the skill and ingenuity of the worker. It may be said that no branch of the metal trades presents a greater opportunity for the development of constructive ability. Efficiency in this line of work requires not only the expert interpretation of drawings and sketches but also the ability to develop views and to supply those details of construction not required on the drawing.

In order to arrange and construct a pattern so as to require a minimum amount of foundry labor, an intimate knowledge of molders' working materials, appliances, and methods is necessary.

A knowledge of machine-shop practice is often helpful when special provisions are required to facilitate the finishing of surfaces and to provide means of securing the castings in a machine tool while the operation of planing, boring, or milling is being done.

Patterns used by the ancients in the casting of bronze pieces were evidently made of wax, which was worked into the form of the desired object. A semiliquid or plastic refractory clay was then poured over or worked about the pattern, and at the completion of this operation, the mold was set aside to dry. An aperture or gate was provided for the removal or the outflowing of the melted wax and for the pouring in of the molten bronze. Small ventholes were also made for the escape of any gases arising from the metal or to release the air displaced by the same.

To remove the wax pattern, the mold was heated and thus caused the wax to melt and flow from its cavity, which was now ready to receive the metal. Because of the destruction of the pattern in the process of making of the mold, this was a slow and expensive method. Nevertheless, its use has come down through the ages, and the principle is applied today in the field of art.

In the advancement of the casting process, there has simply been an extension in the range from that of wax to more durable pattern material and from the use of clay to sand. With the advent of machines and their multiplicity of parts, an increasing demand was made for more intricate castings. This requirement necessitated the use of accurate and durable patterns and led to the adoption of certain woods. Wood was selected as the standard medium because it was found to possess the necessary qualities for the construction of large and small patterns at a moderate cost.

Metal patterns are chiefly employed when a great number of castings are required since they will withstand continued

usage and are impervious to moisture. Metal patterns are usually cast from aluminum and require the making of wooden master patterns. Gypsum or what is better known as plaster of paris is also used for this work.

It is only in the production of small castings of certain requirements that a pattern may be made an exact counterpart of the object to be cast. Hence, it may be said that practically all patterns will require that certain special features must be embodied in their construction so as to facilitate the operation of molding as well as to produce a casting of the required form and dimension.

This textbook is not *intended* to teach molding, but, since patternmaking precedes and supplements this work, it is of the *utmost importance* that the elementary principles of molding be understood in order to see clearly the close relation that exists between these two branches of the metal trades. In some instances the illustrations of the molds as shown are not complete since they do not wholly present the gate and riser arrangements.

The tools used in wood patternmaking do not differ materially from those employed by other woodworkers, except in the case of special tools that the particular need of the trade has developed. However, the conditions of accuracy and other requirements relative to the construction of patterns leave little in common between this artisan and those engaged in other woodworking crafts.

MACHINES AND TOOLS

The equipment of pattern shop should include such machine tools as a combination saw bench, a band saw, a thickness planer, a jointer, a vertical boring machine with an assortment of Forstner bits, a trimmer, a disk and a spindle sander, an oil grinder, a saw-filing and setting machine, a motor stand mounting a cotton buffing wheel about 8 inches in diameter, and a ¾-inch-face hard-felt honing wheel.

The lathe equipment should include a drill chuck and a two-jaw chuck for mounting work. All machines should be guarded with the latest safety devices. To help in the elimination of dust, all saws, planers, and sanding machines should be connected with a blower system.

The miscellaneous equipment should include an automatic glue heater, a medium-sized surface plate, with its adjuncts the step blocks and surface gage, a bench for the finishing and shellacking of patterns, and a set of ⅛- and ¼-inch steel stencils (letters and figures). Special tools should include a core-box plane, a soled plane, a drawknife, a large steel square, and large inside and outside calipers.

The Tool Kit

In planning a patternmaker's tool kit, the following list of tools will be found adequate for the ordinary run of work.

Awl—brad, 1¼-inch blade, flat point
Bench brush
Bevel, 8 inches
Bit—expansion, ⅝ to 1¾ inches
Bits—auger, ¼, 5/16, ⅜, 7/16, ½, and 9/16 inch
Bits—Forstner, ½, ¾, and 1 inch
Bits—twist, 3/32, ⅛, 5/32, 3/16, and 7/32 inch
Brace—ratchet, 8-inch sweep

Calipers—outside, spring, 5 inch
Calipers—inside, spring, 6 inch
Calipers—outside, firm joint, 10 inch
Chisels—paring, $\frac{1}{8}$-, $\frac{1}{4}$-, $\frac{1}{2}$-, and 1-inch straight shank, long beveled edge
Chisels—paring, $1\frac{1}{2}$-inch bent shank, long beveled edge
Cornering tool, $\frac{1}{8}$ and $\frac{1}{4}$ inch
Countersink
Dividers—spring, 5 inch
Dividers—8-inch wing
Fillet irons, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch
Gouges—long bend, carving, $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch, No. 18; $\frac{3}{4}$ inch, No. 16; $\frac{7}{8}$ inch, No. 14
Gouges—short bend, carving, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{5}{8}$, and 1 inch, No. 18
Gouges—paring, $\frac{1}{8}$- and $\frac{1}{4}$-inch straight shank, regular sweep
Gouges—paring, $\frac{3}{8}$-, $\frac{1}{2}$-, and $\frac{5}{8}$-inch bent shank, regular sweep
Gouges—paring, $\frac{3}{4}$-, 1-, $1\frac{1}{4}$-inch bent shank, middle sweep
Gouges—paring, $\frac{1}{2}$-, $\frac{3}{4}$-, and $1\frac{1}{4}$-inch bent shank, flat sweep
Hammer—carpenter, 13 ounces
Hand drill
Knife bench
Leather strop
Marking gage
Nail sets, $\frac{1}{32}$ and $\frac{1}{16}$ inch, cupped point
Oilstone—India, 2×8 inches
Oilstone—slip stone $1\frac{3}{4} \times 4\frac{1}{2}$ inches, $\frac{1}{8}$ and $\frac{3}{8}$ radii
Pincers—carpenter, 6 inch
Pinch dogs, 1 and $1\frac{1}{2}$ inch
Plane—fore, 18 inches
Plane—smooth, 8 inches
Plane—soled
Plane—rabbet, $\frac{3}{4}$ inch
Plane—router
Rule—contraction, $\frac{1}{10}$ inch per foot

Rule—contraction, $\frac{5}{32}$ inch per foot
Rule—contraction, $\frac{2}{10}$ inch per foot
Rule—standard
Saw—crosscut, 20 inch, 8 point
Saw—compass
Screw driver—bits, $\frac{1}{4}$- and $\frac{3}{8}$-inch width of tip
Screw driver—$\frac{3}{16}$ inch in diameter, $4\frac{1}{2}$-inch blade
Screw driver—$\frac{5}{16}$ inch in diameter, 6-inch blade
Spokeshaves—$1\frac{1}{2}$- and $2\frac{1}{2}$-inch blades
Square—combination, center head and protractor
Trammels

Turning Tools

Spear point, $\frac{3}{4}$ inch
Turning chisels—$\frac{1}{2}$, 1, and $1\frac{1}{2}$ inch
Gouge—1 inch
Parting tool—$\frac{5}{8}$ inch
Round-point tools—$\frac{3}{8}$ and $\frac{3}{4}$ inch
Skews—$\frac{3}{8}$ and $\frac{3}{4}$ inch, right- and left-hand
Double bevel—$\frac{3}{4}$ inch

The usefulness of tools depends upon the condition in which they are kept.

Pattern-shop Supplies

Abrasive cylinders
Abrasive disks
Abrasive grains
Alcohol
Brads and nails
Brushes, round glue
Brushes, round marking
Brushes, shellac—set in rubber
Cement, abrasive disk
Chalk, white and blue
Corrugated fasteners, divergent
Dowels, metal and wood
Dusters, bench

Fillets, leather and wax
Garnet, paper
Gasoline
Glue, organic
Glue, synthetic
Oil, machine, kerosene
Oxalic acid
Pattern, letters and figures
Pattern woods, white pine, mahogany
Pattern coatings
Pigments, coloring
Plaster, plaster of Paris
Plastic wood
Polishing rouge
Rapping plates
Shellac, orange flake
Waste, white cotton
Wax
Wood screws

The various sizes of brads and wood screws listed below are those chiefly used for patternwork.

BRADS

½ inch No. 20	1½ inch No. 15
⅝ inch No. 19	1¾ inch No. 14
¾ inch No. 18	2 inch No. 14
1 inch No. 17	2½ inch No. 13
1¼ inch No. 16	3 inch No. 12

WOOD SCREWS

½ inch No. 6	1 inch No. 12
⅝ inch No. 7	1¼ inch No. 12
¾ inch No. 8	1½ inch No. 12
⅞ inch No. 9	1¾ inch No. 12
1 inch No. 10	2 inch No. 14
1¼ inch No. 10	2½ inch No. 14
1½ inch No. 10	3 inch No. 16

PART I

BENCH WORK

PATTERN WOODS

Wood possesses certain qualities necessary in the construction of large and small patterns at moderate cost that are found in the same degree in no other material. Woods are selected that have a comparatively straight, close grain, that

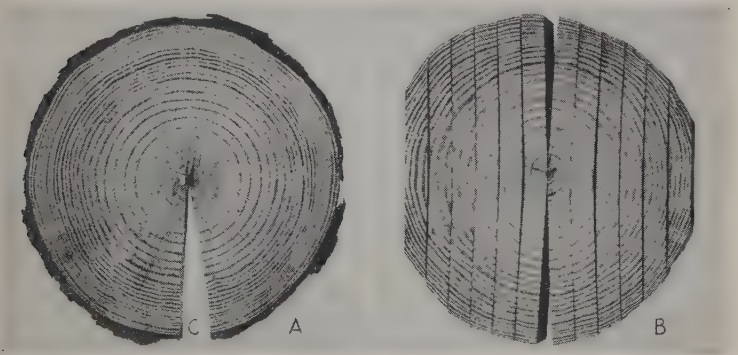


FIG. 1.—*A*. Cross section of a log showing annual layers. Note how the variation in the shrinkage along the layers has caused a wedge-shaped separation of the wood structure as at *C*; *B*. Cross section of a log sawed up into boards. Note the permanent cupping of the boards, the result of the tendency of the segments of the annual layers to shorten and flatten out due to shrinkage.

may be easily worked, and that have little tendency to change shape when exposed to moisture. The best grade comes from matured trees, the structure of which has become compact through the drying out of the sap.

If the cross section of a log, as shown in Fig. 1*A*, be closely examined, it will be observed to be made up of concentric layers or rings. The layers are made up of numerous little tubes or cells and are the means of conveying the sap throughout the tree. They are commonly known as *annual* or *growth rings*, and since a new one appears each year the tree continues

to grow, the approximate age of the tree can be closely reckoned by the number of rings.

The varying amount of moisture in wood changes the diameter of the tubes or cells, thereby causing the board to shrink or swell in width and thickness but not in length, since the tubes lie in this direction. Warping is always the result of shrinking or swelling and may be understood as meaning any change or variation from a flat or plane surface of a board.

When a log is sawed into boards, as shown in Fig. 1*B*, the tendency of the boards is to cup (curl), as shown, from the side that was toward the heart of the log. This is because a greater amount of shrinkage takes place in the wood tissue toward the outside of the tree. Observation shows that a board cut from the center of a log, having an equal distribution of the growth ring segments, is likely to remain straight. Boards having an irregular grain are not to be depended upon to retain their form and therefore should be avoided. Wind, as applied to a board, means that a board is twisted. This distortion may be caused by an irregular grain or by the fact that a board does not lie flat while drying.

The presence of an unusual amount of pitch in a board is betrayed by its weight, which will be excessive. Such a board will prove hard to work and will not make a dependable pattern. Only dry lumber should be used for patternwork. A dry board will feel dry to the hands and, if free from pitch, will be reasonably light.

If a well-seasoned board, planed straight and true, be laid upon a flat surface for any length of time, the tendency of the upper surface will be to curl up or warp. This is due to the upper or exposed side drying out more freely than the underside, which is protected from the air. For this reason, after planing stock to thickness, it should always be placed so that the air may circulate freely about it.

Kiln-dried Lumber.—Kiln-dried lumber is lumber artificially dried, the drying being hastened by placing the boards in a specially designed room called a *kiln*.

Seasoned or Air-dried Lumber.—Seasoned lumber is lumber that is permitted to dry naturally under sheds; in both cases the boards are so piled as to allow a free circulation of air.

Seasoned lumber is said to be superior to kiln-dried lumber, for it is claimed that the rapid drying destroys much of the natural elasticity of the wood fibers.

Of the woods chiefly employed for pattern purposes, white pine continues to furnish the principal supply. White pine is light, soft, and straight grained and can be worked easily to a smooth surface. It does not warp, shrink, or check so much as most other woods. Its glue-holding qualities cannot be excelled, and no other wood can be more easily penetrated and secured with nails and screws than that of pine.

Mahogany is often selected for patterns that are used for making many castings. Like pine, it is not likely to become distorted, and, when straight grained, it is worked with comparative ease. Harder wood, such as maple, is often used for fragile parts or sections of patterns that are subjected to rough usage.

The thickness of standard rough-pattern lumber is 1, 1¼, 1½, 2, 2½, and 3 inches. It comes in various widths from 8 inches and up. In length it runs from 12 to 14 and 16 feet.

A board foot is understood to mean a piece of wood 1 inch thick by 12 inches wide by 12 inches long. To compute the number of feet in a board, multiply the length in feet by the width in inches by the thickness in inches, and divide the product by 12.

The conventional order in which stock is listed is thickness, width, and length. The thickness and width are listed in inches and the length in feet and inches, as ⅞ by 4¼ inches by 3 feet 3½ inches. The term *length*, as applied to a piece of stock, refers to its dimension in the direction of the grain of the wood, regardless of its width.

In roughing out stock, allow at least ¼ inch in width and ½ inch in length for dressing to required size. *Rough out at one time the necessary amount of stock to complete the job.*

THE PLANE

The plane is a tool that has been made in a great variety of forms so as to meet the varying conditions found in woodworking. The most familiar type of plane is illustrated in Fig. 2. It is the one used in patternmaking. Planes are classified according to their length. Those below 14 inches in length are termed *smooth planes;* those from 14 to 16 inches, *jack planes;* those from 18 to 26 inches, *fore planes;* and those from 28 to 30 inches, *jointers.*

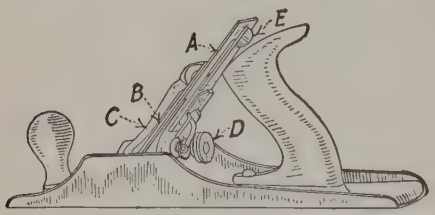


FIG. 2.—Type of plane used by patternmakers.

Long planes are used for large surfaces and in the planing of edges of boards so that they can be closely fitted together. The longer the plane the more accurate will be the surface produced.

There are two chief adjustments in the plane illustrated. When the bit *A* is secured in the plane with the clamp *C*, the use of the thumbscrew *D* will move the bit up or down, and thus the thickness of the shaving to be taken from the material can be regulated. By the use of the lever *E*, located under the bit and working sidewise, the cutting edge of the bit is brought into position with the sole or face of the plane. The bit *A* and cap *B* are secured together with a screw. The function of the cap *B* is to stiffen the bit and to prevent chattering.

The splitting of the wood in advance of the cutting edge of the bit is prevented by the curling up and breaking of the shaving as it hits against the cap. The cap is set back about $\frac{1}{32}$ inch from the cutting edge of the bit.

Form the habit of sighting along the sole before beginning to plane, in order to see that the adjustment of the bit is correct.

The beginner must first learn how a tool must be sharpened; he must then acquire, by practice, the knack of doing it.

Grinding a Plane Bit.—When the repeated whetting of a plane bit has increased the angle or rounded the ground surface of the bit to the extent that it does not cut easily or smoothly, it should be ground. The included angle of the cutting edge should be ground to approximately 22 degrees. Figure 3 illustrates a plane bit being ground. The bit is moved back and forth across the face of the stone.

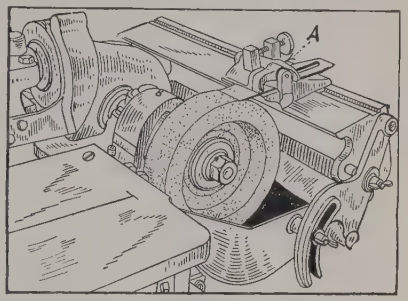


FIG. 3.—A plane bit held in a fixture while being ground on an abrasive wheel.

The Oil Grinder.—The oil grinder has succeeded the large grindstone in the modern pattern shop. Figure 3 illustrates a plane bit held in a fixture at *A*. A groove in the platform engages the holder. The holder is caused to move back and forth in front of the stone.

In grinding a plane bit or any edge tool, particular care must be taken not to bear on too hard, or the edge of the tool will become overheated and the temper lost. Edge tools are ground with the stone revolving toward the tool.

Whetting.—Following the grinding, the plane bit is *whetted* upon an oilstone to a keen cutting edge. The ground surface of the bit is placed upon the stone, as shown in Fig. 4. While steadily held in this position, the bit is rubbed over the face of the stone, along an elliptical path. Passing the bit over the surface of the stone along an elliptical path produces a straight cutting edge and causes the surface of the stone to be worn down more evenly.

For the beginner, the plane will be found a little more easy to operate if the cutting edge of the bit is given an amount of crown (rounded to the extent of a thin shaving). In whetting, crown is given the edge by exerting a little more pressure toward the ends of the edge.

As one becomes more experienced, the cutting edge should be kept straight and the corners slightly rounded. To avoid unnecessary grinding, the bit should be held against the oil stone as near at the angle to which it was ground as possible.

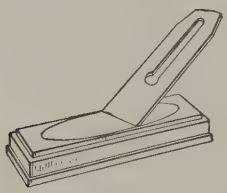


Fig. 4.—Whetting the ground surface of a plane bit upon an oilstone.

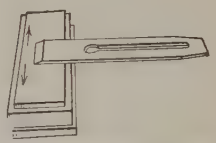


Fig. 5.—Whetting the face of a plane bit upon an oilstone.

If the cutting edge on the face of the blade is examined after this operation, a slight roughness, or what is called a *wire edge*, will be found. The wire edge is removed by holding the face of the bit flat upon the stone, as shown in Fig. 5, then rubbing it back and forth in the direction of the stone's length. By reversing the operation of whetting first the ground surface of the bit, then the face of the bit, the wire edge is removed. That the flatness of the face of the bit may not be impaired, always hold the face of the bit firmly down upon the stone.

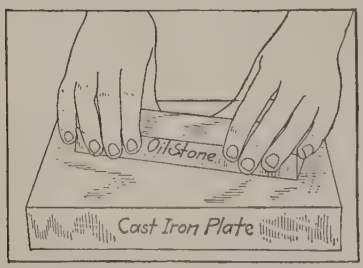


Fig. 6.—Truing up the surface of an oilstone with the aid of abrasive grains.

Free use of oil washes off the small particles of metal cut from the tool and prevents the glazing of the surface of the stone.

Testing the Edge.—The sharpness of the edge may be tested by lightly drawing the tip of the thumb along it. If it feels rough or jagged, it has not been properly whetted. If the edge has been properly whetted, it will score the skin deeply enough to be felt, and it will be realized that a slight pressure will cause it to cut through. The edge of a bit made dull through usage will feel smooth, and it should be whetted.

Stropping.—Following the whetting of a plane bit, the edge is stropped by being drawn over the surface of a strip of leather affixed to a block. In stropping the edge, always hold the bit so as to keep the ground surface of the bit as near at the angle to which it was ground as possible and the face of the bit flat upon the surface of the leather.

Truing Up the Surface of an Oilstone.—When the surface of an oilstone shows indications of wear or becomes uneven, it should be trued up. This is done by moistening the finished surface of a cast-iron plate with gasoline, then sprinkling over it a small amount of abrasive grains. The surface of the stone is then applied to the surface of the plate, as shown in Fig. 6. The stone is rubbed over the surface of the plate along a circular path.

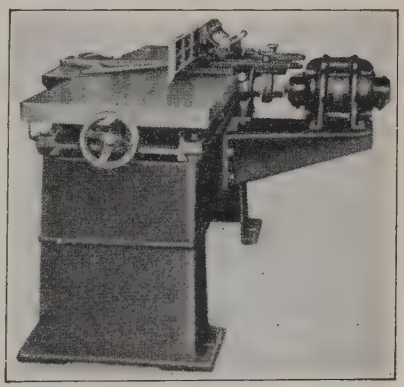


Fig. 7.—Motor-driven planer or jointer.

An abrasive is one of several extremely hard tough substances that, when broken up into small particles or grains, has many sharp cutting edges. The loose grains are used for various purposes or are bonded together in hundreds of shapes and sizes of wheels. The sizes of the particles are designated as *grains* and are graded from coarse to fine. Of these grades 24 to 30 will be found most effective in truing the surfaces of oilstones.

The Jointer.—The jointer, as illustrated in Fig. 7, is a planing machine. The various planing operations to which it lends itself make it one of the most useful adjuncts to a pattern-shop equipment. The size of a jointer is specified by the length of the head or knives in inches and is known as an 8 inch or a 12 inch, accordingly.

QUESTIONS

1. What qualities should wood for patternwork possess?

2. From what kind of trees is the best lumber cut?

3. What is understood by year or growth rings?

4. How is the sap conveyed throughout a tree?

5. How may the age of a tree be closely reckoned?

6. What causes a board to shrink or swell?

7. Why does moisture not affect a board in the direction of its length?

8. Why is the surface of a board that was toward the heart of the tree likely to become convexed during the drying process?

9. Why is a board more likely to remain straight when cut from the center of a log?

10. How may the straightness of grain in a board be determined?

11. How is the presence of an unusual amount of pitch in a board betrayed?

12. Why should a board containing an unusual amount of pitch be avoided?

13. What causes a board to curl up when laid upon a flat surface?

14. What precaution may be taken to keep a board from warping?

15. What is kiln-dried lumber? What is seasoned or air-dried lumber?

16. Why is seasoned or air-dried lumber superior to kiln-dried lumber?

17. What woods are chiefly used for patternwork?

18. For what work is a smoothing plane chiefly used?

19. For what work is a jack plane chiefly used?

20. For what work is a jointer chiefly used?

21. What is the object of the cap that is attached to a plane bit?

22. About how far back should the cap be set from the cutting edge of the bit?

23. To about what angle should a plane bit be ground?

24. What is likely to occur if too much pressure is exerted upon a tool while it is being ground?

25. In whetting a bit, what is the object in causing it to follow an elliptical path?

26. What does the term *crown* mean, as applied to the cutting edge of a bit?

27. In whetting a plane bit, why should it be held against the stone as near to the angle to which it was ground as possible?

28. What is understood by the term *wire edge?*

29. How is a wire edge removed?

30. How may the sharpness of the cutting edge of a plane bit be tested?

31. How may the surface of an oilstone be trued up?

32. In what direction should the grinding wheel revolve with respect to the tool being ground?

33. Why should plenty of oil be used on an oilstone?

BENCH JOB 1

Features presented:

Planing

Testing with a try square surfaces that are at right angles

Gaging of lines

Laying off distances

Scribing lines with a knife

Band-sawing

Figure 8 is the drawing of bench job 1.

In beginning work on a job or pattern, it should be definitely understood what is to be made, how it is to be made, and

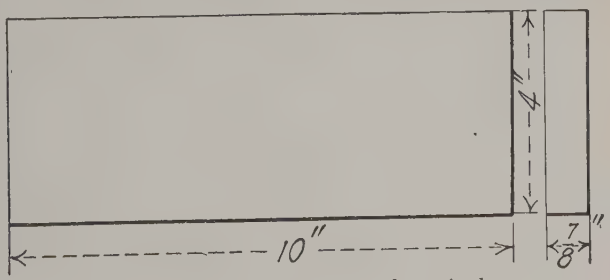


FIG. 8.—Drawing of the board required.

why it is to be made in the manner chosen. For this reason, the student should carefully read all the instructions before beginning work.

Pencil lines, although accurate enough for many purposes, are inexact in defining close dimensions. A scratch or a dent cannot be called a line, and carelessness in this direction will be manifested in the finished work.

No feature in pattern construction requires greater care than the correct establishing of true surfaces or lines from

which dimensions are to begin. No work is more important than that relating to the location and production of these surfaces and lines. Lines drawn in the direction of the grain of the wood are to be scribed with the gage. Lines that lie across the grain of the wood are to be scribed with the knife. Knife lines must be deep and clean cut. The expression "work to the line" means splitting the line.

Planing a piece of work to given dimensions is a reducing process. In order to accomplish this, the rough stock is sawed larger than the size of the object when completed. The amount of waste material to be removed will depend somewhat upon the size and shape of the object. For the ordinary run of small objects, $\frac{1}{8}$-inch thickness, $\frac{1}{4}$-inch width, and $\frac{1}{2}$-inch length will be found sufficient.

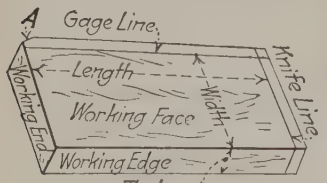


FIG. 9.—The length and width dimensions of the board laid off upon the material.

The job to be made is a rectangular board of a given thickness, width, and length. Figure 9 shows the work in process of making; the wood has been planed to the required thickness, the working end planed, and lines representing the width and length dimensions scribed upon each face.

The stock required is 1 inch thick, $4\frac{1}{4}$ inches wide, and $10\frac{1}{2}$ inches long, or, as usually written, $1 \times 4\frac{1}{4} \times 10\frac{1}{2}$ inches.

ORDER OF OPERATIONS

1. Plane true one face of the material; for reference, call and mark it the *working face.*

If there be any warp or wind in the surface of a board to be planed, this should be determined first. This is done by tilting the plane on its long corner edge while the worker looks between the board and the plane toward the light. The plane must be placed in various directions across the board. If the distance between the diagonal corners of the board exceeds the length of the plane, then the straight edge of a strip must be used for testing the surface.

In planing a surface of a board that is in wind, the high corners are noted and planed down first. The first plane stroke should be along the edge, either beginning or ending at a point near the center of the length of the board. The next stroke should be somewhat shorter, and the strokes should continue to decrease as the planing proceeds toward the middle of the width of the board. To terminate a cut at about a certain point in the board's length, the toe of the plane is lifted. When the wind has been removed, proceed to plane the entire surface.

The Bench Stop.—The bench stop, as indicated by *A* (Fig. 10) is the most efficient way of holding material to be planed, flat upon the bench. If the direction of the cut is kept parallel with the long edges of the surface being planed, the material will not shift its position.

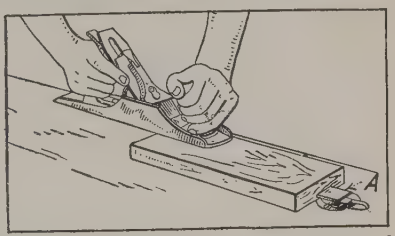


FIG. 10.—Planing the face of the board while held against a bench stop.

Place the end of the board as shown against the bench stop, and take a position well back, so that the plane may be pushed to arm's length.

Do not make the mistake of trying to take a heavy cut.

Should the grain of wood tear out and the surface become rough, turn the board around so as to begin the stroke from the opposite end of the board and with the grain of the wood. Note the effect on the planed surface.

Since about two-thirds of the plane's length overhangs the end of the board when the stroke is started, the forward end of the plane should be held down firmly, by pressure exerted upon the knob, until the plane is well on the board, at which time the pressure should be the same on both knob and handle. As the forward end of the plane passes off the board, the pressure should be exerted upon the handle.

A true surface cannot be produced unless the sole of the plane lies flat upon the board throughout the length of the cut. As the planing proceeds, the trueness of the surface should be

tested from time to time with the long corner edge of the plane.

2. Plane straight and square with the working face one of the edges of the material; call and mark it the *working edge*.

An edge surface of a board is more easily planed if the board is held in a vise.

The Try Square.—The accuracy of the working edge in its relation to the working face is tested with a try square, as shown in Fig. 11. Hold the square loosely in the right hand, grasping the stock as shown. Press the edge of the stock firmly against the working face, allowing the edge of the blade to touch lightly the surface of the working edge. The edge should be tested throughout its length.

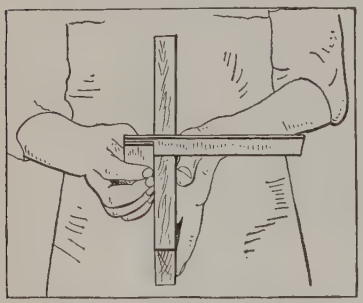


FIG. 11.—Testing the edge of the board with a try square.

From one of these two dressed surfaces, working face and working edge, all other dimensions of the board are to be gaged or squared preparatory to reducing the material to size.

3. Set the marking gage to the required thickness of board; then from the working face, gage lines upon the ends and edges.

Marking Gage.—The marking gage is used for gaging lines parallel to a corner edge of a board. It consists of a bar that carries a sliding head. The head is secured at any point in the bar's length by a thumb nut. The spur that does the scribing is inserted through the bar near one end. The gage is set to the approximate distance, then the final adjustment made by lightly tapping the end of the bar on the bench to move it in or out.

A dimension is taken from a rule with a marking gage, as shown in Fig. 12*A*. The marking gage is used as shown in Fig. 12*B*. The depth of a gage line is regulated by tilting or rolling the gage from you. The spur should be kept sharp so that it will produce a clean-cut line. The head of the gage

must always be kept firmly pressed against the surface from which the lines are being gaged. Failure so to hold the gage will result in the spur leaving its desired course.

4. Plane the material to thickness; split the line.

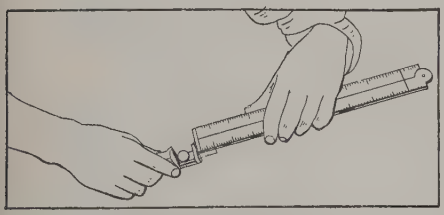


FIG. 12*A*. —Taking a dimension from a rule with a marking gage.

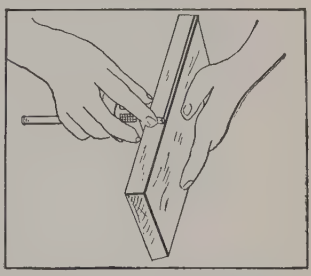


FIG. 12*B*.—Gaging upon the edges of the board the required thickness.

5. From the working edge, gage the required width of board upon each face.

Caution: Do not dress the board to width.

6. With backsaw (Fig. 17*A*), chamfer (about ⅛ inch) the corner as at *A* (Figs. 9 and 13). Chamfering the corner is

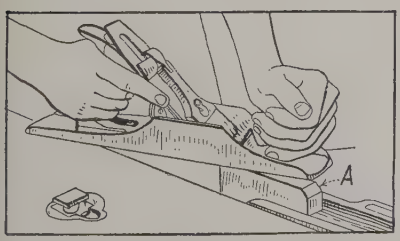


FIG. 13.—Planing the end surface of the board while held in the vise.

FIG. 14.—Testing the end surface of the board with a try square.

to prevent the splitting out of the grain of the wood while the end surface is being planed.

7. Plane straight and square to working face and working edge one of the ends of the material; call and mark it the *working end*.

The board is held in the vise as illustrated in Fig. 13. Hold the plane at an angle as shown, in order that the fiber of the grain of wood shall be severed by a shearing cut.

The plane is held at an angle, but the direction of the stroke is parallel with the long edge corners of the surface being planed. The squareness of the corner formed by the working edge and the working end is tested with the square, as shown in Fig. 14.

FIG. 15.—Laying off from the working end, the length dimension of the board.

8. Lay off from the working end the required length of the board, and scribe a knife line around the material (see Fig. 9).

The length dimension of the board is laid off by placing the rule upon its edge, as shown in Fig. 15. While the 10-inch graduation mark is made to coincide exactly with the edge corner of the working end, the point of the knife is placed at the end of the rule as shown.

The try square with the stock bearing against the working edge is now slid along until the blade of the square touches the blade of the knife, as shown in Fig. 16. Hold the stock of the square firmly against the working edge, and draw the knife along, pressing it lightly against the blade of the square. To prevent the knife from running away from the blade of the square, turn the edge of the knife slightly toward the blade.

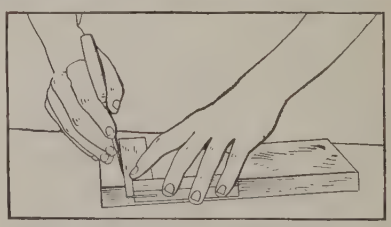


FIG. 16.—Squaring a line across the face of the board with the aid of the square and knife.

9. About $\frac{1}{16}$ inch outside or on the waste side of this line, saw off the waste material. Do not saw to width.

10. Chamfer the corner as at *A* (Fig. 13); then plane the end surface down to the line.

11. About $\frac{1}{16}$ inch on the waste side of the line representing the width of the board (Fig. 9), saw off the waste material; then plane this edge surface down to the line. The waste material may be removed with an ordinary hand or backsaw, as shown in Fig. 17*A*, or sawed off with a band saw, as shown in Fig. 17*B*. The size of a handsaw (rip or crosscut) is specified

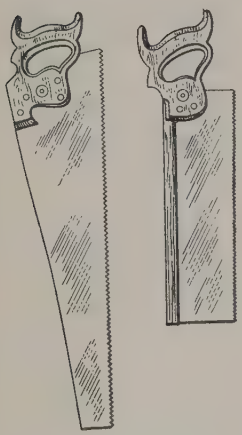


FIG. 17*A*.—Type of handsaw used by patternmakers.

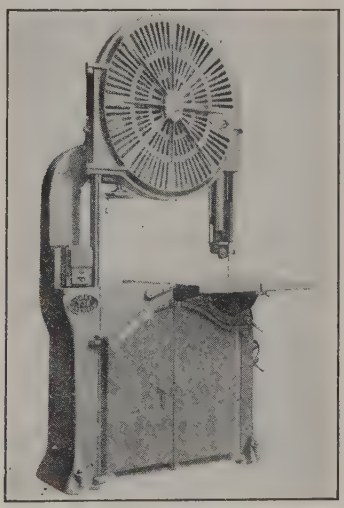


FIG. 17*B*.—Type of band saw used by patternmakers.

by the length of the blade in inches and the number of teeth points in 1 inch.

The Band Saw.—The band saw, as illustrated in Fig. 17*B*, is used for all kinds of curved and combinations of straight and curved sawing. The table may be tilted 45 degrees to the right and 30 degrees to the left.

The size of a band saw is specified by the diameter in inches of the wheels over which the saw runs. The size of band saw blades is specified as follows: width of blade in inches, number of teeth points in 1 inch, and the length of the blade in feet and inches.

QUESTIONS

1. What should be definitely understood before beginning work on a job?

2. What is the advantage of lines scribed with a knife over those drawn with a pencil?

3. What tool is used to scribe lines that lie in the direction of the grain of the wood?

4. Why is a knife used to scribe lines that lie across the grain of the wood?

5. What does the term *splitting a line* mean?

6. What is understood by the term *working face? working edge? working end?*

7. Why is the accuracy of these surfaces very important?

8. What is understood by the term *warp* or *wind*, as applied to a board?

9. How is a board tested to determine if it is warped?

10. How is a board tested for wind?

11. What is the procedure in reducing with the plane a surface that is in wind?

12. What is a bench stop?

13. How should the pressure be distributed upon a plane from the beginning to the completion of a cut?

14. How is the accuracy of the working edge in its relation to the working face tested?

15. Describe and give the names of the different parts of the marking gage.

16. How is the final or close adjustment of a gage made?

17. Why should the head of the gage always be held firmly against the surface from which the line is being gaged?

18. What is the object in holding a plane at an angle to the face of a board in planing end grain wood?

19. What may be done to prevent the splitting out of the wood in planing the end of a board?

20. How should the rule be placed upon a surface in laying off or measuring a dimension?

21. Name in order the operations required in planing a board to a given thickness, width, and length.

22. What are the standard thicknesses of mill-sawed lumber?

23. How should the blade of a knife be held to prevent it from leaving the blade of the square?

24. What is the conventional arrangement used in listing the dimensions in ordering material to be cut to size?

25. How does a backsaw differ from the ordinary hand saw?

26. How is the size of a band saw blade specified?

BENCH JOB 2

Features presented:

Laying out an irregular object

Planing obliquely to the grain of the wood

Figure 18 is the drawing of bench job 2.

Careful workmanship is the foremost requirement in patternmaking and should be developed from the very start. The job to be made is a board of an irregular outline.

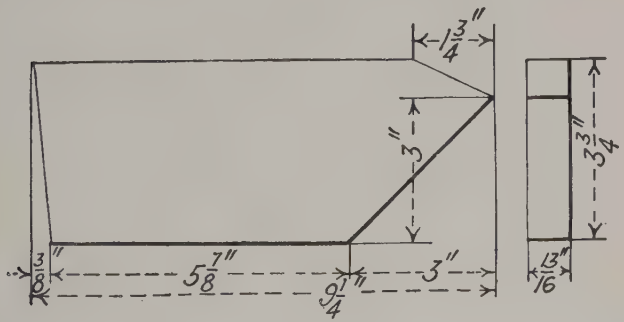


Fig. 18.—Drawing of the object to be made.

The ends of the object are not square with the edges but form angles other than 90 degrees. This job not only assists in the development of accuracy in laying out work but affords practice in planing surfaces that lie obliquely to the grain of wood.

Figure 19 shows the laying-out diagram. For the purpose of reference, letters are used to designate the given dimensions of the object. The wood has been planed to the required thickness, the working edge prepared, and the shape of the object laid out upon each face of the material, preparatory to sawing and planing it to shape.

In planing a surface that lies in a direction oblique to the grain of the wood, always plane from the point or angle nearest the center of the length of the board toward the end of the surface. If the cut is taken in the opposite direction, the grain of the wood will have a tendency to be raised by the plane bit and torn out instead of being severed. The arrowheads (Fig. 19) clearly indicate this method.

Particular attention is called to the fact that the layout on both sides of the material is to be made following the sequence of steps as listed. If the layout is made on one side

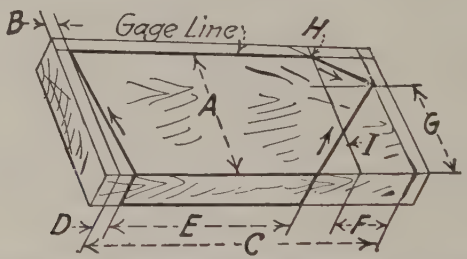


FIG. 19.—The laying-out diagram, showing the shape of the object laid out upon the material.

and then on the other, an unnecessary handling of tools will result. Following the steps as listed promotes accuracy and eliminates loss of time.

At the completion of a layout, carefully check or verify all dimensions of the object with those on the drawing.

Stock required: $1 \times 4 \times 10$ inches; or the object may be made from the preceding job.

ORDER OF OPERATIONS

1. As in the preceding job, plane the material to the required thickness of the object, and make a working edge.

Note: For the bench jobs and patterns to follow, this operation will be known as *preparing the material.*

2. Begin the layout by gaging upon each face the width dimension of the object as represented by the letter *A* (Fig. 19).

3. Determine how much longer the material is than the object; lay off one-half this amount from one end, as represented by the letter *B*, and scribe a line about the material.

4. From this line, lay off the over-all length of the object, as shown by the letter *C*, and scribe this line about the material.

5. Lay off, and scribe lines across the working edge, which represent the dimensions *D*, *E*, and *F*.

6. Dimension *F* locates the line *I*; scribe this line across each face until it intersects the gage line at *H*.

7. From the working edge, gage the distance *G*; then complete the layout by connecting the points thus located with well-defined knife lines. Use the blade of the square as a straightedge in scribing these lines.

8. About $\frac{1}{16}$ inch outside the lines that represent the angular ends, saw off the waste material. Do not saw to the width.

9. Plane the end surfaces down to the center of the knife lines. See instructions for planing these surfaces.

10. Saw and plane the object to the required width.

QUESTIONS

1. What is to be understood by an oblique line or surface?

2. Why is it usually good practice to plane the end surfaces of a board before planing the board to width?

3. In sawing a job to its rough outline, how much marginal waste should be allowed for planing the job to its required size?

4. Why should the layout of a job be made upon both sides of the material?

5. What is the foremost requirement in patternmaking?

6. What does "prepare the material" mean, as applied to the work?

7. What is to be gained by following the steps as listed in laying out bench job 2?

8. What is to be learned from bench job 2?

9. What distinct advantage has the band saw over the backsaw?

10. How is the size of saw teeth specified?

BENCH JOB 3

Features presented:

Application of center lines
Application of the dividers
Chisel paring

Figure 20 is the drawing of bench job 3.

No other feature in patternwork assures greater accuracy than that of true center lines. Their purpose is to serve as

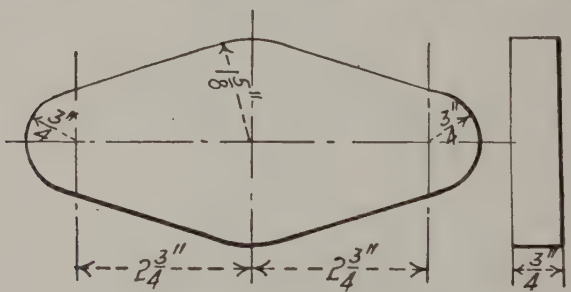


FIG. 20.—Drawing of the object to be made.

a basis or starting point from which dimensions are to be measured.

This job presents the use of center lines. It will show the error that will result if they are not accurately scribed or placed in their proper relation to one another.

If the intersection of center lines *A*, *B*, and *E* (Fig. 21) does not locate on one face, directly opposite the intersection point on the reverse face of the material, the edge surface of the object will not be true to form.

The operation of checking or verifying the dimensions of a pattern with those on the drawing requires that all center lines appear upon the finished work.

Figure 21 shows how the shape of the object is to appear upon both faces of the material, when it is ready to be sawed to within about $\frac{1}{16}$ inch of its scribed outline.

Stock required: $\frac{7}{8} \times 3\frac{3}{4} \times 7\frac{1}{2}$ inches.

ORDER OF OPERATIONS

1. Prepare the material. Plane to the thickness of object.

2. Gage center line *A* upon each face along the middle of its width.

3. At the middle of the length of center line *A*, locate and scribe about the material the center line *B*.

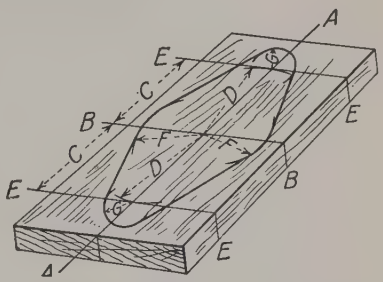


FIG. 21.—The laying-out diagram showing the shape of the object laid out upon the material.

4. From the intersection of center lines *A* and *B*, lay off upon *A* the dimensions represented by *C*. This operation is done with the aid of the dividers by scribing arcs as indicated

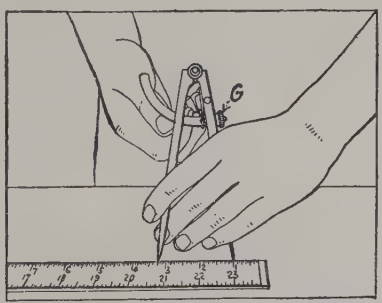


FIG. 22.—Taking a dimension from a rule with the dividers.

by *D*, then scribing the lines *E* tangent to (touching) the arcs as shown.

Dividers.—Dividers are used for measuring distances between points, for transferring distances taken from a rule, for scribing arcs and circles, and for subdividing lines. Figure 22 shows how a dimension is taken from a rule with dividers of the wing type.

Wing dividers are provided with an adjusting nut as indicated by *G*, which is very useful in adding to or subtracting from the original setting.

In using dividers, grasp them in the right hand at the top, where the two legs are joined together. In scribing a circle, rotate the dividers from left to right around to the starting point. Go over the surface very lightly. Any attempt to scribe a deep line will probably cause the point to follow the grain of wood, thus resulting in an irregular line.

Whenever distances are the same about a given point or each side of a center line, as the dimension represented by *C*, the dividers are used to lay off these distances.

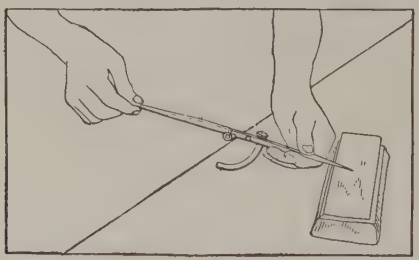


Fig. 23.—Sharpening the points of the dividers upon an oilstone.

The points should always be kept sharp. This is done by holding the point on an oilstone as shown in Fig. 23 and, while passing it back and forth in the direction of the stone's length, rotating it one way and then the other.

5. Scribe across each face of the material the center lines *E*.

6. Set the dividers to the dimension represented by *F*, and, with the intersection of lines *A* and *B* as the center, scribe arcs as shown.

7. Set the dividers to the dimension represented by *G*, and, with the intersection of lines *A* and *E* as the center, scribe semicircles as shown.

8. Complete the outline of the object by scribing lines tangent to the arcs *F* and *G*.

9. Saw within $\frac{1}{16}$ inch of the scribed outline.

10. Plane to the center of the lines that are scribed tangent to the arcs, and, with a paring chisel as shown in Fig. 24, pare to the center of lines of the scribed arcs.

The Paring Chisel.—The paring chisel, as shown in Fig. 24, is a long thin chisel with either square or beveled edges.

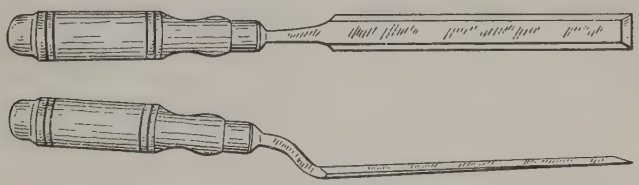


FIG. 24.—Bevel-edged paring chisel with a bent shank.

Chisels 1¼ or 1½ inch in width are chiefly used for paring. Grasp the chisel in the right hand, well down on the blade, as shown in Fig. 25. Hold the material firmly with the left hand, at the same time guiding the chisel along the line with the thumb. As pressure is exerted upon the chisel, it is drawn to the right or left, producing a slicing cut.

Tilt the handle slightly toward the left hand to avoid undercutting the surface. Pare from one face and then from the

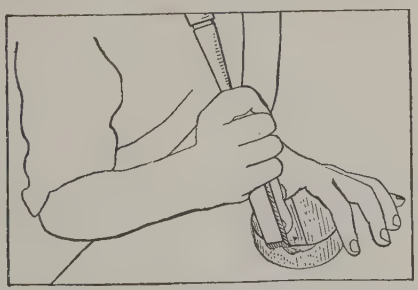


FIG. 25.—Position of holding the paring chisel while paring a convex-edged surface.

other until a true surface is produced. As the paring proceeds, the surface should be tested with the long corner edge of the chisel.

A chisel is ground and whetted in the same manner as a plane bit.

BENCH JOB 4

Features presented:

Scribing an arc the center of which lies outside the limit of the material

Gouge paring

Grinding a paring gouge

Whetting a paring gouge

Stropping the edge of a gouge

Figure 26 is the drawing of bench job 4. This job consists of a rectangular figure containing a concave surface in each edge.

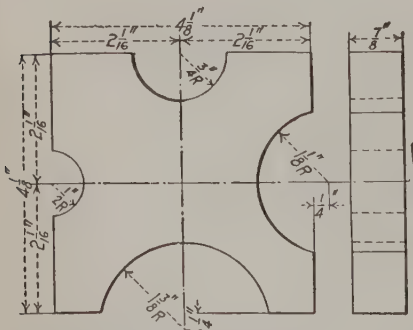


Fig. 26.—Drawing of the object to be made.

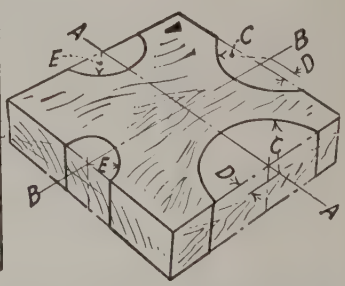


Fig. 27.—The laying-out diagram, showing the shape of the object laid out upon the material.

Figure 27 shows the shape of the object as it is to appear; upon each face of the material the concave surfaces are ready to be shaped.

Frequently the center of an arc will fall upon the edge or outside the limit of the material, as in the case of the radii *C* (Fig. 27). To locate such centers, square up two edges of a block; then square a line across one of the surfaces. Upon this line, gage the distance represented by *D*.

To scribe the arc, locate and firmly hold the block against the edge of the work, as shown in Fig. 28. Except for the purpose of illustration there is no particular reason why the spring dividers, as shown, be used in preference to the wing dividers. When the center occurs upon the edge of the material, as in the case of radii *E*, it is necessary only to hold a block against this surface.

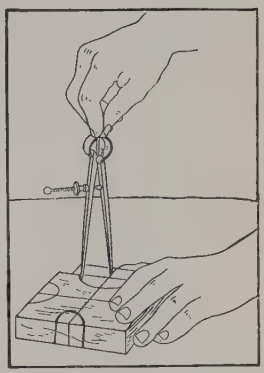


FIG. 28.—Locating and supporting the point of the dividers outside the limit of the material while scribing an arc.

When the layout of an object has been completed, the scribed or gaged lines may be further defined with a medium-hard chisel-pointed pencil.

The Paring Gouge.—The paring gouge, as shown in Fig. 28*A* is a companion to the paring chisel. When straight or convexed surfaces are to be reduced by paring, the chisel is used. When concave surfaces are to be pared, the paring gouge is used. The arc of the blades of paring gouges are made in three sweeps termed, full, middle, and flat, with the radii of the arcs varying with the widths of the blades. The blades range from $\frac{1}{8}$ to 2 inches in width. A paring gouge has the angle of the cutting edge ground on the inside or concave face of the blade.

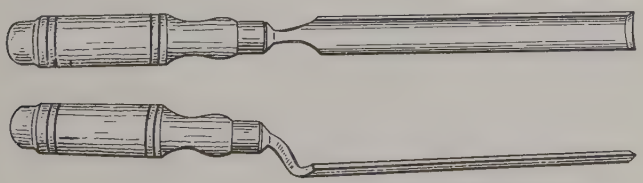


FIG. 28*A*.—Paring gouge with a bent shank.

Paring gouges like chisels may also be obtained whose handles are offset so that they will not be in line with the blade. This arrangement permits the gouges to be used for paring across wide surfaces or for the dressing out of long grooves.

The general outline of job 4 being of regular form, the material is more easily planed to the length and width dimensions before the concave surfaces are dressed to shape.

Stock required: $1 \times 4\frac{3}{8} \times 4\frac{1}{2}$ inches.

ORDER OF OPERATIONS

1. Prepare the material.
2. Dress to length, then to the width dimension.
3. Scribe the center line *A* at the middle of its length, and gage the center line *B* along the middle of its width.
4. Scribe the outline of the concave surfaces; then establish their width upon the edges by scribing knife lines across the edges, as shown.
5. Remove the excess waste material of openings with band saw. One-sixteenth inch is to be allowed upon the wall of the openings for paring the surface to the required outline.

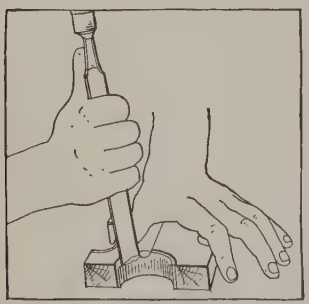


Fig. 29.—Position of holding the paring gouge while paring a concave-edged surface.

If a saw blade of $\frac{1}{4}$-inch width were used, it would be possible to saw to the line of the scribed arcs made with a $1\frac{1}{8}$- and $1\frac{3}{8}$-inch radius. For the beginner, it will be safer to make a series of straight cuts, $\frac{1}{16}$ inch apart, at right angles to the edge of the material and within $\frac{1}{16}$ inch of the line, then break out the material between the saw cuts.

6. Select a gouge of the same or of a slightly less radius than the surface to be pared.
7. The gouge is grasped well down on the blade by the right hand, as shown in Fig. 29.

While pressure exerted by the thumb of the left hand holds the work, it at the same time controls the placing of the cutting edge of the gouge. As pressure is placed upon the gouge, it is slightly oscillated and thereby caused to sever the grain of wood more easily and smoothly. Tilt the handle of the gouge slightly toward you to prevent undercutting.

Pare from one face of the material and then from the other until a true surface is produced. As the paring proceeds, the surface should be tested with the long corner edge of the gouge.

Grinding.—A narrow convex-faced abrasive wheel is best suited for this work. Keep the gouge rocking one way and then the other so that the surface ground may be continuous and the thickness of the cutting edge uniform.

Hold the gouge lightly so that it may be guided by a sensitive touch.

The contact between the gouge and the stone must be of short duration and the edge of the gouge cooled by submerging it in water between applications.

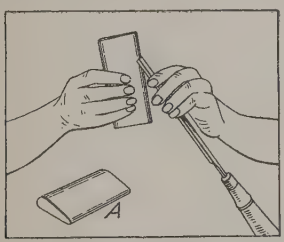


FIG. 30.—Whetting the concave face of a paring gouge with a slip stone.

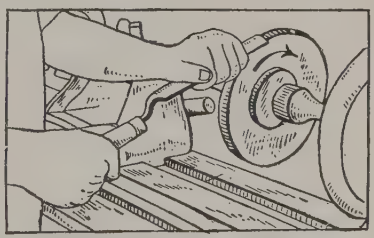


FIG. 31.—Felt wheel used to produce a keen cutting edge on a paring gouge.

Whetting.—Figure 30 illustrates how a paring gouge is whetted. Hold the slip stone at the proper angle to the face of the blade. Give the slip stone a lengthwise movement, at the same time moving it back and forth along the entire length of the cutting edge.

Round-edged Slip Stone.—The type of slip stone used by the patternmaker is of a diminishing thickness, as shown at *A*.

Hold the convexed face of the blade firmly down upon an oilstone, and give it a rocking motion while moving it back and forth in the direction of the stone's length.

To sharpen the edge further, it is stropped by drawing first the concave, then the convex face over a piece of flexible leather.

The Polishing Wheel.—Figure 31 illustrates a polishing wheel made from hard felt. When used with good judgment and an extremely fine grade of polishing material, it becomes a

very useful device in sharpening gouges. A wheel made up of several thicknesses of cotton cloth will greatly aid the sharpening of gouges of small concavities. A polishing wheel revolves away from the tool.

QUESTIONS

1. In what direction should the cut be made in planing a surface that lies obliquely to the grain of the wood?

2. What is understood by the expression *check the layout of the work?*

3. What is a straightedge?

4. What is the object of center lines?

5. For what purposes are dividers used?

6. What should be avoided in scribing an arc or a circle upon the surface of wood?

7. What is understood by *tangent?*

8. What is understood by the expression *chisel paring?*

9. How is a slicing cut produced with a chisel?

10. What is the difference between a chisel and a gouge?

11. Is the angle of the cutting edge of a paring gouge ground on the convex or concave face of the blade?

12. Why is a gouge slightly oscillated about its axis when used for paring?

13. How is the angle of the cutting edge of a paring gouge best ground?

14. What is likely to happen if too much pressure is placed upon a tool in grinding it?

15. What is understood by the term *whetting?*

16. What is understood by the term *stropping?*

17. How is the selection of a paring gouge made in regard to the surface to be dressed?

18. What is a slip stone?

19. How are the points of dividers sharpened?

20. How should dividers be held in scribing an arc or circle?

21. When equal distances are to be laid off on each side of a center line, what tool should be used?

22. What is the difference between the wing dividers and the spring dividers?

23. How is the size of a chisel specified?

24. How is the arc of a gouge specified?

25. What will be the result if the center lines are not placed in their proper relation to one another upon each face of the material?

26. What advantage have chisels and gouges with the offset or bent shank over those with the straight type?

27. What type of polishing wheels is used for sharpening gouges?

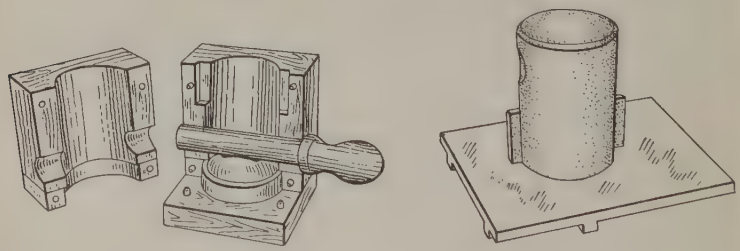
A SAND MOLD

The most common mold (green-sand mold) is formed by ramming damp molding sand about a pattern contained within a surrounding frame called a *flask*. Dividing the body of the sand into at least two separate parts will permit a complete impression to be made of the pattern and will also allow the pattern to be drawn from the sand. When a mold is made up of two sections, it is said to be a two-part mold and will consist of a drag, or bottom section, and a cope, or top section. The relative positions of the cope, drag, and the bottom board are shown in Fig. 32. To permit the sections of a mold to be separated, then later returned and registered together correctly, the flasks are fitted with pins and sockets as shown. Convenience more than anything else determines whether the pin member shall be placed upon the drag or the cope. However, the general practice has been to place the pins upon the drag. The joint or surface that separates two sections of a mold is called the *parting*. The surface of a pattern exposed when the cope is removed is called the *parting* or *cope surface* (cope face). The surface that leaves its impression in the sand of the drag is called the *drag surface* (drag face). A sand mold is destroyed in the making of a casting, but any number of molds may be made by the use of a single pattern.

FIG. 32.—The relative positions of the cope, drag, and the bottom board of a two-part flask.

In a broad sense, the term *core* is applied to that part of a mold or body of sand which is to form a corresponding hole,

cavity, or the interior of a casting. Cores may be formed of either green or dry sand; those made of green sand are usually formed or left in the mold by the drawing out of the pattern. as at *A*, Fig. 51. For this reason, they may therefore be considered a part of this body of sand. Cores made of dry sand not only are used to form the interior of castings but are also extensively employed to form exterior surfaces of castings in order to facilitate the molding of the patterns. The term *green sand* simply means that the sand is used in its natural state, sands being selected that contain a sufficient bond-clay content that when the sand is slightly moistened it will retain an impression of a pattern. Baked cores (dry sand) require a



A *B*

Fig. 33.—*A*. A core box consisting of four parts; *B*. The core formed in the box. The core is resting upon a metal core plate.

silica-sand mixture (ground rock). Since sand of this kind contains no inherent bond to hold it together, an artificial bond is supplied in the form of wheat flour, linseed oil, resin, etc., Dry-sand cores are given shape by ramming the sand into specially constructed forms called *core frames* or *boxes*. A core box is shown in Fig. 33*A*. A core that was formed within the walls of the core box is shown in Fig. 33*B*, resting upon a metal core plate ready to be placed in an oven and thoroughly dried.

Making a Mold of a Simple-shaped Pattern.—1. The first step in the process of making the mold is to place the pattern cope face down upon the molding board *A* at about the middle of the length of the flask and about 4 inches from one side, as shown in Fig. 34. In this instance, the 4 inches of space is to

allow for the gating of the mold. The drag part of the flask is now placed in position upon the molding board, joint edge down (pins down).

2. Sift sand through a *riddle,* as shown in Fig. 35*A*, over the pattern to a depth of about 1½ inches; then, using the

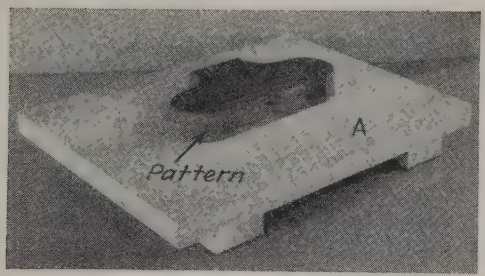


FIG. 34.—The pattern upon the molding board, the first step in the process of making a mold.

fingers of both hands, tuck the sand around the edges of the pattern and against the sides of the flask.

The sand is passed through a riddle to remove any lumps or foreign matter that might deface the surface of the mold.

3. Fill the drag slightly more than full with unriddled sand, and with the peen end of a rammer, as shown in Fig. 35*B*, ram the sand firmly around the walls of the flask. Now refill the drag, heaping full, and proceed to butt-ram the sand. Ram the sand that lies next to the sides of the flask first and then the sand toward the middle, until the sand has been packed down evenly over the entire area. The surplus sand is now scraped off with a strickle (straightedge) until it is even with the edges of the flask. *Note:* It is of the utmost importance in the making of good castings that the sand of a mold is

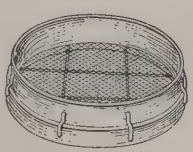


FIG. 35*A*.—Riddle used in sifting the sand over the pattern.

FIG. 35*B*.—Rammer used in tamping the sand about the pattern.

rammed to the right degree of hardness. This knowledge is acquired only through experience and observation.

4. With a venting needle, as shown in Fig. 36, vent freely (pierce) the sand that lies over the pattern and also the sand surrounding it. Be careful that surface of the pattern is not defaced by being struck too violently with the needle.

FIG. 36.—Venting wire or needle used in venting the sand.

5. Place and rub a bottom board, as shown in Fig. 32, firmly down upon the edge of the flask. Now, while securely holding the molding board and the bottom board in place, turn the drag over. The removal of the molding board will now expose the parting surface of the mold and will also show the pattern in its true molding position (Fig. 37).

6. With a trowel, as shown in Fig. 38, slick out any rough-

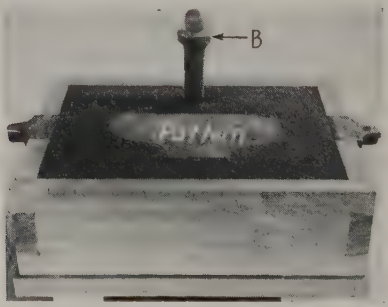


FIG. 37.—The pattern in its true molding position, the second step in the process of making a mold.

ness appearing upon the parting surface, and then dust over the surface from a cotton bag, parting sand, or *compound* to prevent the sand of the drag and that of the cope from adhering together. Any parting material that may have fallen upon the pattern should be blown off with the bellows, as shown in Fig. 39.

7. Set the sprue plug *B* about in line with that of the center of the pattern and about 2 inches away from it, as shown in Fig. 37. The metal will enter the mold at a point opposite the sprue plug. This location is selected because the plane-

ness of the surface at this point will facilitate the removal of the gate from the resultant casting.

8. Place the cope upon the drag, and riddle sand over the pattern as heretofore explained. Tuck the sand firmly around the sprue plug and against the sides of the flask. The cope is now rammed up, the sand struck off, and this section of the mold vented.

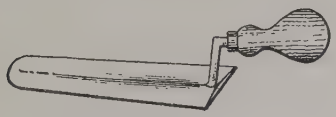


FIG. 38.—Trowel used in slicking the parting surface of the mold.

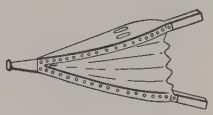


FIG. 39.—Bellows used in blowing any loose sand from the mold.

9. Slightly tap, and then draw out the sprue plug, and with the thumb press down any loose sand about the opening. The cope is now lifted off and set to one side, as shown in Fig. 42, and the sand adjacent to the pattern very slightly moistened with the aid of a water brush, as shown in Fig. 40*A*. Moistening the sand increases its resistance to breaking and also aids in the repairing of the edges of the mold if necessary.

FIG. 40*A*. Water brush used in moistening the sand adjacent to the parting line of the pattern.

FIG. 40*B*. Draw spike used in drawing the pattern.

10. Draw the pattern from the sand with the aid of a draw spike, as shown in Fig. 40*B*. The draw spike is driven into the pattern at about its center of balance. Then, while the spike is lightly rapped from right to left, the pattern is gently lifted upward out of the sand. Should any slight breaks appear along the edges, they are to be repaired with the aid of tools similar to those shown in Fig. 41*A*.

11. With a gate cutter, as shown in Fig. 41*B*, form the gate, as shown at *C* (Fig. 42), that is to conduct the metal from the

sprue opening *B* into the mold. To ensure a steady flow of metal entering the mold as well as to cause the gate to break off close up to the casting, the gate may be made about ¼

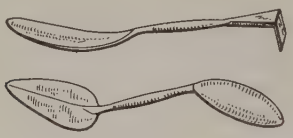


FIG. 41*A*.—Lifter and spoon type of tools used in finishing molds.

FIG. 41*B*.—Gate cutter used in cutting the gate leading from the sprue opening to the mold.

inch deep by ¾ inch wide where it enters the mold, increasing in proportion to a point below the sprue opening.

12. When all loose sand has been blown from the mold, dust or brush over its surfaces a facing of graphite, and close the

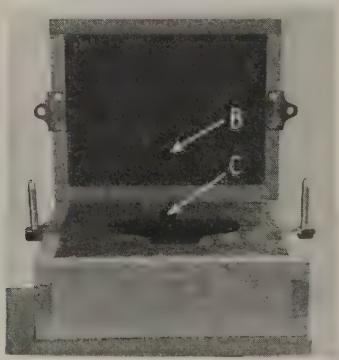


FIG. 42.—The completed mold ready to be closed.

mold. Graphite is a mineral form of carbon. It is applied to the surface of a mold in order to resist the heat of the metal and thereby give a smooth surface to the casting.

Making the Mold of on Irregular-shaped Pattern.—It was learned from the previous molding problem that the parting surface of a mold made from a plain flat pattern is formed by the molding board, whereas a pattern having an uneven cope surface as that shown in Fig. 43 causes the parting

surface of the mold to be irregular. Whenever the cope surface of a pattern is such that the parting line occurs below the joint of the drag section of the flask, it is said to be coped out. The reason being that the sand of the cope is caused to extend downward below the joint of the flask, and thereby complete its impression of the pattern. This condition will require, in most cases, that a part at least of the parting surface

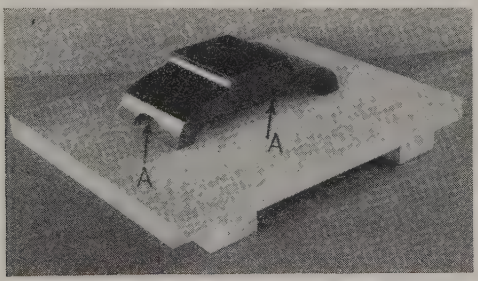


FIG. 43.—The pattern upon the molding board.

must be given shape by hand, before proceeding with the work upon the cope.

1. The first step toward the completion of this mold is to place the pattern upon the molding board at about the center of its width and length, as shown in Fig. 43, and set the drag in place.

2. Cover the pattern well with riddled sand; then, while holding the pattern firmly down with one hand, tuck the sand around it and well into the openings occurring at *A*, between the pattern and the molding board. Then fill the drag with sand and proceed with the ramming and venting operations and the rolling over of the drag as previously instructed.

3. Upon the lifting off of the molding board, remove from the pattern all loose sand; then, with the aid of a spoon, as shown in Fig. 41*A*, shape the parting surface to conform to that of the parting line of the pattern as at *B* (Fig. 44). The surface made by cutting away the sand should be made to extend outward from the pattern at least 1 inch. It should then be made gradually to incline upward to the

level of the surface produced by the molding board. Surfaces formed by cutting or scraping away the sand will probably be found rough and will require slicking down with a finishing tool.

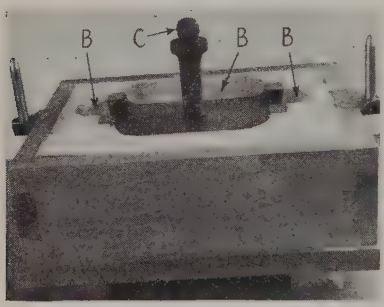


Fig. 44.—Shows how the surface of the sand of the drag has been made to conform to the parting line of the pattern.

4. At the completion of the parting surface apply the parting material, and set the sprue plug in place, as shown at *C* (Fig. 44). Now proceed with the ramming and the venting of the cope. If it is desired, this mold may be gated from the side, as was done in the case of the former job. However, because of the irregular parting and the nature of the required casting, pouring the mold from directly above will be found more convenient.

5. Draw out the sprue plug, and then lift off the cope. Because of the unevenness of the irregular parting surface, this will require more care and attention than if it were a plain parting. Be careful to hold the flask level and steady as it is lifted upward far enough to give ample clearance between all surfaces.

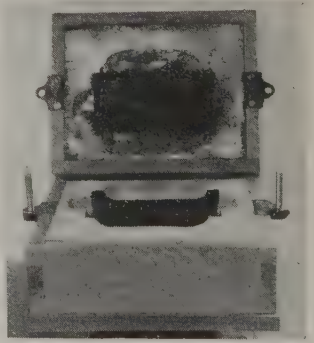


Fig. 45.—The completed mold ready to be closed.

6. The open mold is illustrated in Fig. 45. The pattern has been drawn, the mold cleaned and given a facing of graphite, and is now ready for closing.

QUESTIONS

1. What is a sand mold?
2. What is a flask, as used in making a mold?
3. Give the names of the sections of a two-part flask.
4. What means are used to hold the sections of a flask together?
5. For what purpose is a bottom board used?
6. What is to be understood by the term *green sand?*
7. Name the joint or surface that separates two sections of a mold.
8. Can more than one casting be made from a sand mold?
9. What is the meaning of the word *core*, as applied to a mold?
10. Why are some cores called *dry-sand cores?*
11. What is silica sand, or what is commonly called core sand?
12. What is the difference between green sand and core sand?
13. What does the word *bond* mean, as applied to sand?
14. What is the nature of the bond found in green sand?
15. Name some materials that are used as bonds in core sand.
16. How are dry-sand cores formed?
17. For what purpose is a core box used?
18. For what purpose is a core plate used?
19. For what purpose is a molding board used?
20. What section of a flask is usually rammed up first?
21. Name the three parts of a rammer.
22. When should the peen end of a rammer be used?
23. For what purpose is a strickle used?
24. Why is the sand of a mold vented, and how is it done?
25. What does the molding position mean as applied to a pattern?
26. For what purpose is a trowel used?
27. What is done to prevent two parts of a mold from sticking together?
28. For what purpose is a bellows used?
29. For what purpose is a sprue plug used?
30. About how far from a pattern should a sprue plug be set?
31. What is the purpose of riddling sand over a pattern?
32. By what means may a pattern be drawn from the sand?

Reminder

Consult Glossary of Patternmaking and Molding Terms.

PATTERN FEATURES

Pattern.—The term *pattern,* as used in connection with founding, is applied to a form modeled in any material from which a mold may be made of sand.

Parting Line.—On every pattern there must be a surface on which the parts of a pattern or its mold separate. It is this factor that determines the molding position of the pattern and the arrangement of its mold. No definite rule can be given as a guide for the establishment of a parting line, for its location will be governed primarily by the nature of the casting to be made.

Draft.—Draft may be defined as the *angle of slant* tending away from a parting line. It is given those surfaces of a pattern which lie parallel to the direction the pattern or its component parts are drawn from the sand. The purpose of draft is to aid in the release of the pattern from the sand with the least of disturbance to this body. It will therefore be seen that the surfaces requiring draft will be determined by the molding position selected for the pattern. Draft allowance may be changed to meet certain molding conditions, but, unless otherwise instructed by the text, allow from $\frac{1}{64}$ to 1 inch of draw. By adding this amount to the dimensions given on the drawing, the cope surface of the pattern is made larger.

Shrinkage and Contraction.—Shrinkage and contraction of metals are the result of the action of cohesion or that force which draws together molecules of the same kind. Although shrinkage and contraction are a part of the same process that lessens the size or volume of metal while it is cooling, many engaged in making castings think of these two actions as quite different. For instance, shrinkage is thought of as the arranging of the molecules or as that of the changing

of the structure of the metal as it passes from a liquid to a solid state. Contraction is observed as immediately following shrinkage and is thought of as the amount that the metal will have decreased in size when its temperature has fallen to that of normal. The figures for linear expansion, or its reverse action, contraction, have been determined for all the common metals.

It will readily be seen that if the pattern were made the required size of the object, the casting made from it would be found undersize by an amount equal to the contraction of the metal. In order to compensate for the decrease in size of the casting, it is necessary to make the pattern larger by this amount. If the standard rule were used in dimensioning patterns, it would be necessary in laying out the work to calculate and allow for the contraction. This, however, is eliminated by the use of contraction rules.

Contraction or Shrinkage Rule.—It is a rule with the graduations so enlarged as to compensate for the lessening in the size of a casting during the cooling period. Metals do not contract alike, and it is therefore necessary to have rules varying in contraction allowance.

The amount per foot that metal will contract in cooling will depend somewhat upon the size, the shape, and the metal mixture composing the casting. For instance, if it is of an open construction it will be likely to contract more than a casting of the same weight but of a cored construction. Although the contraction amounts as given in the accompanying table are approximate, they are accurate enough for the general run of castings.

TABLE OF CONTRACTION ALLOWANCE PER FOOT

Cast iron	$\frac{1}{10}$ inch	Bronze and brass	$\frac{3}{16}$ inch
Cast steel	$\frac{3}{16}$	Aluminum	$\frac{5}{32}$
Malleable cast iron	$\frac{1}{8}$	Magnesium	$\frac{5}{32}$

The contraction allowance for small patterns may often be disregarded, as the rapping of the pattern will usually enlarge the mold enough to offset the amount of contraction taking place in the casting.

QUESTIONS

1. Why is a strip of sand adjacent to the pattern slightly moistened before drawing a pattern?
2. By what means is the metal conducted from the sprue opening to the mold?
3. Why should the smallest part of the gate be at the point where it enters the mold?
4. Why is a facing of graphite applied to the surfaces of a mold?
5. For what purpose is a water brush used?
6. What is graphite?
7. When is the parting surface of a mold formed by hand?
8. What is the purpose of rapping a pattern?
9. What is patternmaking?
10. What is a foundry pattern?
11. What is the parting line of a pattern?
12. What pattern feature determines the position of a parting line?
13. What is to be understood by the term *draft* as applied to a pattern?
14. What surfaces of a pattern are given draft?
15. What determines the surfaces of a pattern to be given draft?
16. About how much draft is allowed to each inch of draw?
17. Is a cope surface made larger or smaller by the addition of draft?
18. What is to be understood by the drag face of a pattern?
19. What is meant by the cope face of a pattern?
20. What usually determines the molding position of a pattern?
21. Can a model of an object always be used as a pattern?
22. What is meant by shrinkage as applied to metal?
23. What is meant by contraction as applied to metal?
24. Why is the pattern made larger than the casting required?
25. Why is the standard rule not used in the dimensioning of patterns?
26. What is a contraction rule?
27. How does a contraction rule differ from a standard rule?
28. About how much will cast iron contract per foot?
29. Does brass contract more or less than cast iron?
30. What is the contraction allowance for aluminum and steel per foot?
31. What feature of a casting may affect the amount of its contraction?

Reminder

Never begin work upon a pattern until every detail in its construction is clearly visualized.

PATTERN 1

STOP PLATE

Features presented:

One-piece patterns
Drilled holes
Draft
Contraction
Center lines
Sandpapering patterns
Shellacking patterns

Figure 46 is the drawing of a cast-iron plate.

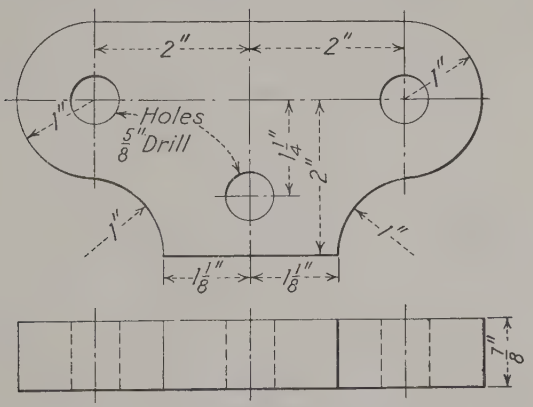


FIG. 46.

The casting consists of an irregular-shaped plate having a thickness of $\frac{7}{8}$ inch. The $\frac{5}{8}$-inch holes in the casting are specified to be drilled. This means that the holes are to be made in the casting by a *metal-cutting* tool known as a *drill*.

The type of pattern required is known as a *one-piece pattern*. One-piece patterns do not necessarily mean patterns that are

made from one piece of wood but patterns whose construction permits them to be molded without joints, partings, or loose pieces.

The general practice followed is to arrange a pattern to mold in the position that requires the least draw. The application of this feature is made to the pattern under consideration.

The plate is to be made of cast iron, which requires the use of a contraction rule having an allowance of $\frac{1}{10}$ or $\frac{1}{8}$ inch per foot.

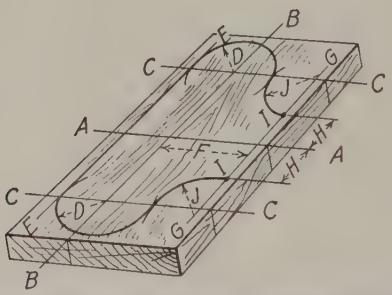


FIG. 47.—The reference diagram, showing the shape of the stop-plate pattern laid out upon the material.

To facilitate the checking of a pattern, all center lines are to be scribed with a sharp knife point so that they will not be obliterated in the finishing of the pattern.

Draft is required on those surfaces of a pattern that parallel the direction in which it is drawn from the sand. The edge surfaces of the plate pattern lie in this direction and therefore will receive this consideration.

Stock required: $1 \times 3\frac{1}{2} \times 6\frac{1}{2}$ inches.

ORDER OF OPERATIONS

1. Prepare the material (see operation 1, page 20).

Figure 47 is the reference diagram; it shows how the shape of the pattern will appear when laid out upon the material.

2. Scribe center line *A* at the middle of the length of the material and gage line *B* $2\frac{1}{4}$ inches from the working edge.

3. From center line *A*, locate and scribe center lines *C* and *C*.

4. Select one face, and mark it the *cope face;* mark the opposite face the *drag face.*

Draft enlarges a pattern of this type toward the parting, or the cope face; therefore, the shape of the drag face of the pattern will be laid out to the given dimensions on the drawing. About $\frac{1}{64}$ inch will be allowed for draft upon the edge surfaces of the pattern.

5. With the intersection of the center lines *B* and *C*, Fig. 47, as the centers, using the radii *D* scribe upon the drag face semicircumferences.

6. Increase radii *D* about $\frac{1}{64}$ inch, and scribe these semicircumferences upon the cope face.

7. Upon the cope and drag face, scribe the line *EE* tangent to the arcs of radii *D*, completing the outline of this half of the pattern.

8. Upon the drag face, lay off the dimension represented by *F*, and gage the lines *GG* parallel to the center line *B*.

9. Add about $\frac{1}{64}$ inch to dimension *F*, and repeat operation 8 upon the cope face.

10. To obtain the points *II* of the drag face, lay off (*with dividers*) upon line *GG* the dimensions represented by *HH*.

11. Add about $\frac{1}{64}$ inch to the dimensions *HH* and repeat operation 10 upon the cope face.

12. Arcs scribed upon the cope and drag face with the radii *J* through the points *I* and tangent to the arcs of radii *D* will complete the layout of the pattern.

13. Saw and dress the work to shape. (Refer to the instructions on chisel and gouge paring given with bench jobs 3 and 4.)

SANDPAPERING AND SHELLACKING PATTERNS

Before a pattern receives its protective coating of shellac, it is sandpapered in order to remove the ridges and marks left by the tools. Cabinetwork requires that sandpapering be done in the direction of the grain of wood. Sandpapering patterns may be done with or across the grain.

All tool work must be completed before proceeding with the sandpapering operation. This method is to be followed until instructions are given to the contrary.

Sandpaper (garnet paper) is graded numerically from fine to coarse, as follows: No. 0000, 000, 00, 0, ½, 1, 1½, 2, 2½. Of these grades, Nos. 0, ½, and 1 are generally used for patternwork.

A coarse grade may be first used and later the surface further smoothed down by the use of a finer grade. The best results are obtained by using the sandpaper over a soft wood block.

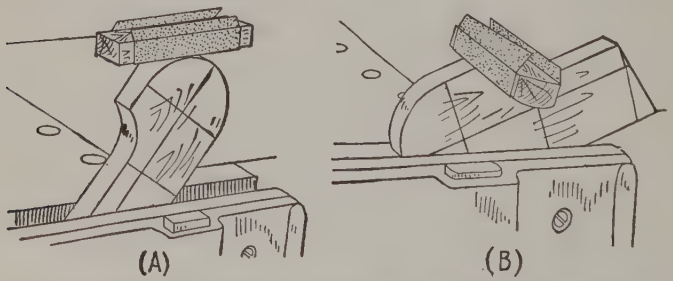


FIG. 48.—*A*. Position of block for sandpapering a convex-edged surface; *B*. Position of block for sandpapering a concave-edged surface.

For flat surfaces, hold the block down firmly, passing it back and forth without releasing the pressure. Figure 48*A* shows how the block is held in sandpapering a straight- or convex-edge surface of an object. Figure 48*B* shows how the face of the block is dressed to conform to a concave surface. A concave surface requires an oscillating movement of the block.

Always sandpaper an edge surface in the direction of its length; if done otherwise, the finished surface will be likely to be found convexed.

PATTERN COATINGS

In order that a pattern may retain its accuracy of form to the greatest degree its surfaces are given a coating of a quick-drying material. The nature of the coating must be such that when dry it will provide a hard smooth finish that is impervious to moisture. It also must be resistant to abrasion and heat,

for without these qualities the surfaces of a pattern are not likely to be cleanly drawn from the sand.

For many years shellac has been the accepted standard coating for pattern work and in all probability will resist for some time to come the general use of the synthetic resin coatings. However, the claim is made that this synthetic product, which is sold under various trade names, competes favorably with shellac.

Since the use of shellac for the coating of patterns is the general rule, it will be herewith considered. Shellac gum is a yellowish substance which is known as *lac* in its native state and is the joint product of an insect and the juice of trees. It is prepared for use by dissolving the shellac gum in alcohol in the proportions of about 3 pounds of gum to 1 gallon of alcohol. This dissolving process is called *cutting shellac.* For cutting a small amount, the proportions of the gum and alcohol may be made about equal parts. If it is then found to be too thick it is thinned by the addition of alcohol.

If shellac is allowed to stand for any length of time exposed to light, it is likely to become discolored but its color may be partially restored by stirring in a *minute* amount of oxalic acid. *Caution:* While oxalic acid will clear the color it is apt to cause some deterioration of the liquid. Shellac is also discolored through its contact with certain metals; therefore, it is best kept in nonmetallic containers or only in those heavily plated with tin or copper. Best results are to be obtained from shellac of a comparatively thin fluidity, for this will flow freely and spread evenly. The number of coatings to be applied will depend upon the amount of protection desired. Two applications are regarded as a minimum and four as a maximum.

See that the surfaces are smooth and free from dust; do not overload the brush; apply the shellac quickly and avoid going over the surfaces more often than is required to spread the coating evenly. Always pass the brush from the work, for if passed toward it the edge of the surface will wipe some of the shellac from the brush and cause it to collect over the bordering surface, where if allowed to dry it will retard the drawing of the pattern and will detract from its appearance.

Shellac will spread a little more uniformly if applied in the direction of the grain of the wood. However, the shape of the pattern will usually determine the direction of its application. The coated surface will appear dry after a few moments but the best results can only be attained by allowing a drying period of at least 1½ hours.

The coating when dry, especially after the first application, will feel rough to the touch. This roughness, which is caused by the liquid raising the grain of the wood, is to be removed with a fine grade of sandpaper, preferably No. 00. The process of sandpapering and shellacking is to be repeated until the desired number of coatings have been applied. All surfaces are then to be checked for smoothness.

A convenient type of pressed-steel, tin-coated shellac container is shown in Fig. 49. The vessel is so designed that the brush is suspended from the rod extending across its interior as shown. This arrangement permits about ½ inch or more of the bristles to be immersed in the liquid when the brush is not in use. Also the suspension of the brush will prevent its weight from resting upon the bristles; if this occurs for any length of time the bristles will become bent and therefore impair the usefulness of the brush. The cone-shaped cover receives the handle of the brush and holds it in a vertical position.

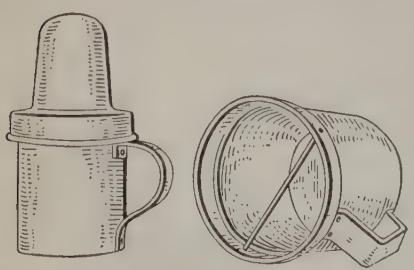


FIG. 49.—Tin-coated, steel shellac container.

Shellac is colored by the addition of coloring matter. If used in a dry state, the pigment should first be dissolved in alcohol and then added to the shellac and thoroughly mixed by stirring.

Standard Pattern Colors.—The American Foundrymen's Association has recommended a color plan for marking patterns. Copies of the markings, which are known as Commercial Standard CS-19-30, are on file with the U.S. Superintendent of Documents, Washington, D.C.

PATTERN 2

WASHER

Features presented:

A green-sand core

Reinforcing a green-sand core

Draft on the walls of small holes and openings

Sandpapering small interior conical surfaces

Figure 50 is the drawing of a cast-iron washer.

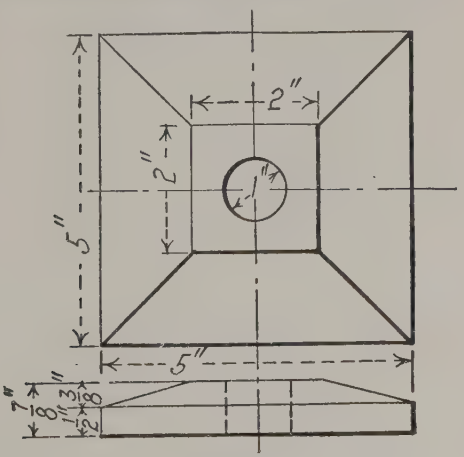


Fig. 50.

As previously explained, the word *core* as applied to a mold is understood as meaning that part of the mold or body of sand that is to form a hole, a cavity, or an interior opening in a casting.

The open mold shown in Fig. 51 illustrates this feature. The letter *A* designates the core. It is that part of the mold, or body of sand, that was delivered by the hole in the pattern.

Excess draft is given the wall of a hole to release the core with the least disturbance. Failure to allow this excess draft upon such surfaces is likely to cause the core to be broken from the adjoining sand and lifted out with the pattern. A measure also taken to prevent such a happening is to reinforce the core by inserting a good-sized *flathead nail* at its center.

Allow on the wall of holes, unless otherwise instructed, $\frac{1}{32}$ to 1 inch of draw. It is assumed that a hole in a casting is to receive a bolt or bar. Therefore, the given dimension of the hole must not be made less by the addition of draft to its wall.

FIG. 51.—The washer mold. The letter *A* indicates the body of sand (core) that is to form the hole through the casting.

The size of the hole at the parting surface is made to the dimension on the drawing, the draft enlarging it toward the drag face. The shape of the washer suggests that the pattern be molded flatwise, with the impression of the chamfered face formed in the drag.

Stock required: $1 \times 5\frac{1}{2} \times 5\frac{1}{2}$ inches

ORDER OF OPERATIONS

1. Prepare the material.

2. The washer being of rectangular form, the material will be dressed to the over-all length-and-width dimension of the pattern.

3. Gage center line *A* along the middle of its width, and scribe center line *B* at the middle of its length (Fig. 52).

4. Mark one face of the material *cope* and the opposite face *drag*.

5. From the cope face gage upon the edges the dimension represented by *C*.

The draft is to enlarge the bolt hole toward the drag face.

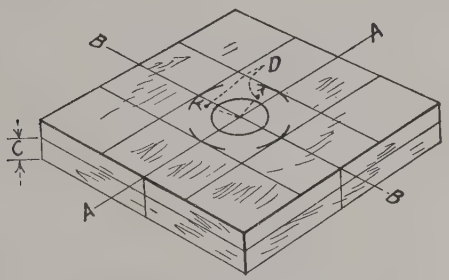


FIG. 52.—The construction lines of the drag face of the washer pattern as they are to appear upon the material.

6. From the intersection of the center lines *A* and *B*, scribe upon the cope face a circumference that is the given diameter of the bolt hole. Provide draft upon the wall of the hole by enlarging the radius $\frac{1}{32}$ inch, and scribe a circumference upon the drag face.

7. To establish the angle of the chamfered surface, set the dividers to 1 inch; then from the intersection of the center lines, scribe arcs *D* as shown.

8. Lines scribed and gaged tangent to these arcs will complete the layout of the pattern.

Figure 52 shows how the construction lines of the pattern are to appear upon drag face when completed and the work ready for the dressing out of the bolt hole.

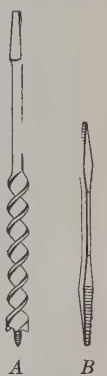


FIG. 53.—*A*. An auger bit. *B*. A bit file.

Check the layout by verifying all the dimensions of the pattern with those on the drawing.

Auger Bits.—Auger bits are made in many styles. The most common type is shown in Fig. 53*A*.

9. Locate a $\frac{7}{8}$-inch auger bit, as shown in Fig. 53*A*, at the intersection of the center lines, and bore a hole. There is less danger of splitting the wood if the hole is bored from each face to the center of the thickness.

A hole is more easily bored perpendicular to a surface if the work is so placed that the bit may be held in a vertical position. Auger bits are made in sizes advancing by sixteenths of an inch from $\frac{3}{16}$ inch up. They are best sharpened with a specially designed file, as shown in Fig. 53*B*. Never file the lip on the underside, since the changing of its angle will impair its cutting efficiency. Use the file on the inside of the spur only. Any roughness caused by filing the spurs should be removed by laying the bit upon an oilstone and revolving it. An auger bit is held in a bit brace (see Fig. 60, page 62).

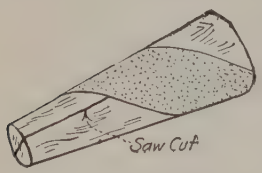


FIG. 54.—Sandpaper roll with the paper attached.

10. With a paring gouge, pare the hole to required size.

11. Chamfer the drag face of the pattern; then slightly draft the edge surfaces.

Tapered holes are best sandpapered with the aid of a conical form, as shown in Fig. 54. Refer to the information given with lathe job 6. By inserting one corner of the paper in the saw cut and wrapping the paper around, as shown, a conical sandpaper surface is made. Insert the roll from the drag face, and revolve in one direction only.

Finish all surfaces of the pattern with the desired number of applications of shellac.

QUESTIONS

1. What is to be understood by a one-piece pattern?
2. What does the term *drilled* mean on a drawing?
3. Why should all center lines appear on the finished pattern?
4. Why is a thorough knowledge of the principles of mechanical drawing and foundry work necessary to become a successful patternmaker?
5. Describe the various operations required in making the mold for the stop-plate pattern.
6. Why is the stop-plate pattern molded flatwise?
7. Why are patterns sandpapered?
8. How is the grit or degree of coarseness of sandpaper graded?
9. How does sandpapering patterns differ from sandpapering cabinetwork?
10. How should sandpaper be used to obtain the best results?
11. Why should narrow-edge surfaces be sandpapered in the direction of their length?
12. How are concave surfaces best sandpapered?
13. Why are patterns given a coating of shellac?
14. Of what is shellac composed?
15. What solvent is used for shellac?
16. Why should a vessel containing shellac be kept closed?
17. What should be avoided in applying shellac?
18. Why should sandpapering the surface precede each coat of shellac?
19. What is understood by the term *cutting shellac?*
20. Why is the use of thin shellac more satisfactory than thick?
21. What nature of a container is best suited for shellac?
22. What small amount of chemical placed in shellac will improve its color?
23. What is the natural color of shellac? How may it be colored?
24. Why is excess draft given the walls of small holes?
25. Why should the draft upon the walls enlarge the given dimension of the hole toward the drag face of the pattern?
26. What is an auger bit? What part is the lip? What part is the spur?
27. How are tapered or conical holes best sandpapered?
28. What is a chamfered surface?
29. How may small green-sand cores be reinforced?

MACHINE FINISH

Machine finish is the operation of removing or cutting from a casting an amount of stock in order to produce a finished surface. Flat surfaces may be machine-finished upon a shaper, planer, or milling machine. For production work, grinding wheels are extensively used.

Figure 55 illustrates one of the machine tools that may be used when finishing a flat surface of a casting. The letter *A* designates the cutting tool, *B* the thickness of the metal (finish allowance) being removed.

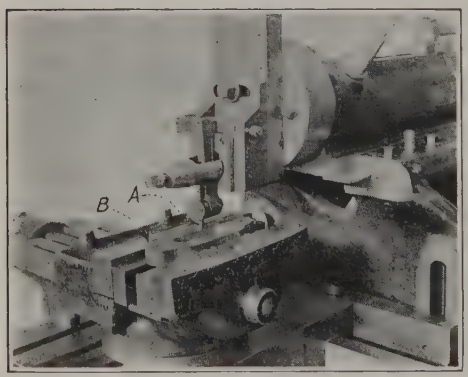


FIG. 55.—Finishing the surface of the platen casting upon a shaper.

The drawing gives the finished dimensions of a casting. The patternmaker is to add to those surfaces indicated by the finish mark symbol $\sqrt{f}$ finish allowance, that the casting may be machined to the given size.

Recently the American Society of Mechanical Engineers adopted for the finish mark an angular V-form symbol to be used in place of the former symbol that has been used on drawings for years past. Since the V-form symbol has not as yet come into general use by drawing departments, the use of the earlier sign will be continued in this text for the present.

One-eighth-inch finish allowance will be allowed on the surfaces of cast iron or steel, unless otherwise instructed.

One-sixteenth-inch finish allowance will be allowed on the surface of brass or aluminum, unless otherwise instructed.

PATTERN 3

PLATEN

Features presented:

The finish mark symbol
Machine finish
Finish allowance for cast iron
Drilled holes
Sandpapering small interior concave surfaces.

Figure 56 is the drawing of a cast-iron platen.

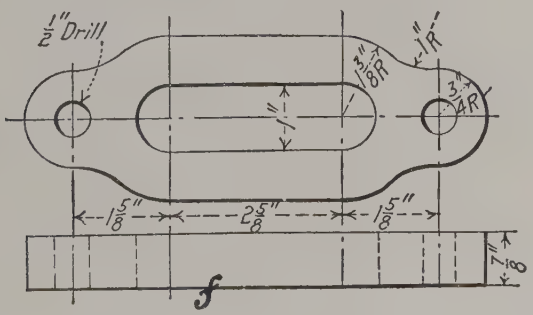


Fig. 56.

A finish mark symbol $\overline{f}$ appears on the line that represents the edge, the only visible part of the surface of the platen requiring machine finish. This means that instead of the platen pattern being made to the thickness given on the drawing (⅞ inch), the thickness is increased (⅛ inch) by the amount that has been allowed for the operation, machine finish.

The ½-inch holes shown near the ends of the casting are specified to be drilled. This means that the holes are to be made in the casting by a metal-cutting tool known as a *drill*.

No pattern consideration is to be given holes that are less than 1¼ inches in diameter, unless otherwise instructed.

The platen pattern will be molded flatwise.

Figure 57 illustrates the shape of the pattern laid out upon the material.

Stock required 1⅛ × 3 × 7⅞ inches.

ORDER OF OPERATIONS

1. Note the location of the finish mark symbol; then prepare the material, and locate the center lines *A* and *B*.

2. From line *A*, lay off, and scribe lines *C* and *C*.

Dimensions are to be laid off from a base line. On this pattern, lines *C* are to be located from the base line *A*. The

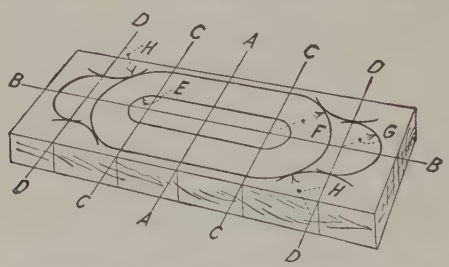


Fig. 57.—The construction lines of the platen pattern as they are to appear upon both faces of the material.

center lines *D* are to be located from the base line *A*. Under no circumstances would the center lines *D* be located from the center lines *C*.

3. Mark one face *cope*, the opposite face, *drag*.

4. Upon the cope face, lay out the width of the slot by scribing semicircumferences, using a radius equal to *E*. Make the draft allowance, and repeat the operation upon the drag face. Slot to have 1/32 inch of draft upon its walls.

5. Upon the drag face, lay out the width of the pattern by scribing semicircumferences, using a radius equal to *F*. Add draft allowance to radius *F*, and repeat the operation upon the cope face.

6. Upon the drag face, lay out the semicircular ends of the pattern by scribing semicircumferences, using a radius equal

to *G*. Make the draft allowance, and repeat the operation upon the cope face. Upon the cope and drag faces, scribe arcs tangent to the semicircumferences already drawn, using a radius equal to *H*.

7. Roughly shape the slot by boring four $\frac{7}{8}$-inch holes tangent to one another.

The lead screw of a $\frac{7}{8}$-inch auger bit is likely to split the wood when holes are bored so close together. Splitting is avoided by first boring holes (pilot holes) whose diameter is about equal to the mean diameter of the lead screw.

The mean diameter of the lead screw of an auger bit is the diameter of the lead screw at the middle of its length.

8. With a paring gouge and chisel dress the slot to size.

9. Saw and dress the edge surface to shape.

Dress, as applied to woodworking, is understood as meaning the shaping of a surface (regardless of the tools used) to its required outline.

Small interior concave surfaces are best sandpapered with the aid of a cylindrical form or roll, as shown in Fig. 58. The roll is given a rotary movement.

FIG. 58.—Method of sandpapering the concave surfaces of the slot in the platen pattern with a cylindrical roll.

A block should be used for the flat surface of the slot. Never use a crosswise motion when sandpapering surfaces of this nature. (Refer to information on sandpapering given with pattern 1. See Figs. 48*A* and 48*B*.)

PATTERN REQUISITES

Materials presented:

Glue
Brads
Wood screws
Wax, plastic, leather, and wood fillets
Fillet cement

Glue.—Of the many adhesive materials employed in the binding together of wood, *organic* or what is better known as *animal* glue is principally used in the field of wood patternmaking. Animal glue will keep indefinitely in a dry state, but once moistened or prepared for use it will deteriorate rapidly. It is for this reason that a greater amount of glue than is likely to be used over a period of two or possibly three days should never be prepared at one time.

To be made ready for use, the glue is placed in a container, covered with *cold water*, where it is allowed to soak until it jellies. It is then heated over boiling water or with an automatic electric glue heater until it becomes perfectly fluid. This thickness is then to be maintained by the addition of hot water. Dry heat in the form of a *flame* is never to be applied directly to the vessel containing the glue, for the glue will then become scorched and thereby rendered unfit for use.

Once the glue has been thoroughly dissolved its temperature is to be reduced slightly below the boiling point, for excessive boiling will not only cause it to thicken but will also lessen its adhesiveness. Never prepare glue in a kettle containing old glue but always boil out the used kettle before putting a new supply to soak.

The essential qualities for a permanently glued joint is a perfect contact between the abutting surfaces of the wood, a properly prepared high-grade glue, and a sufficient degree of clamping pressure exerted upon the material during the drying period.

Spread the glue quickly, rub the coated surfaces together briskly to spread evenly and to remove any surplus glue, and then apply pressure.

Hot glue applied to a cold surface will instantly congeal, and no amount of pressure will bring the abutting surfaces of the material into required contact. Thick glue is to be avoided for the same reason. Never attempt to use glue in a cold room without first heating the joint surfaces of the wood.

For the gluing together of the surfaces of hard wood, tooth planing is recommended. This roughing operation is done with a toothed plane, whose bit is set perpendicular to the sole of the plane and has a cutting edge consisting of minute points.

From 2 to 6 hours are required for a well-made glued joint to dry before the means of clamping pressure should be removed. However, the size of the surfaces and the weather conditions may have some influence upon the length of the drying period.

Glue if directly applied to the porous surface of end grain wood is likely to be absorbed before it has sufficient time to become set. To neutralize this action a primary coating of very thin glue, called *sizing*, should always be given to such surfaces. When the sizing has thoroughly dried, the gluing operation is completed in the usual way. A glued joint made between end grain surfaces is never so strong as when made between length grain surfaces and it is not to be relied upon unless reinforced.

Synthetic Glue.—This glue possesses merited qualities and is being used extensively in many lines of woodworking, but it has not, at least to any extent, entered the field of patternmaking.

Brads.—The common wire brad is chiefly used for small- and medium-sized patternwork. The smallness of the head permits it to be set below the surface of the wood with the least defacement.

The length of brads is given in inches; and the wire gage, or diameter, in number—usually expressed 1¼ inch No. 17, etc. Their selection as to length will depend upon the thickness of material they are to secure and the depth of grip or holding surface that may be obtained in the adjacent piece of wood.

When the thickness of the material will permit, the length of grip should at least equal one half the length of the brad.

If the thickness of the holding material will not allow this proportion, the brad should then be toed or driven in obliquely, to secure sufficient withdrawal resistance.

When the case permits, drive the brad through the material of the lesser thickness into the thicker. A brad driven parallel to the direction of the grain of wood (in end grain wood) does not have the withdrawal resistance that it will have if it is driven at an angle to the direction of the grain.

Fig. 59.—A nail set used in setting a nail head below the surface of the wood.

Place brads as far apart as the work will permit. Strength does not depend so much upon the number of brads as upon the way they are placed and driven. When two or more brads are used in the same locality, they should be so placed (staggered) as to be out of the line of the same fiber of the wood.

Driving a brad through a piece of short grain wood is likely to split it; therefore use the brad as a drill point in a hand drill, and bore a pilot hole; then insert the brad, and drive it home.

Nail Set.—Do not drive the head of a brad down flush with the surface of the wood, but allow it to protrude slightly; then use a nail set, as shown in Fig. 59.

Do not forget that the points of nail sets vary in size.

Do not leave the head of a brad exposed, but set the head below the surface and fill the depression with wax.

Brads should never be used except when they can be so placed as to be in no danger of contact with the tools. Brads are used to good advantage in hastening the work, because they eliminate the use of clamps while the glue is drying.

The common flathead or wire nail is used when greater withdrawal resistance is desired and the largeness of head is not objectionable.

Wood Screws.—Flathead wood screws are used for pattern-work. The advantage of screws is that they are strong, have great power of resistance, and may be easily withdrawn and the work taken apart.

The size of flathead wood screws is designated by their length over-all in inches and by diameter in number of the American screw gage. They are specified as ¾-inch No. 8, 1½-inch No. 9, etc.

The selection of screws of the proper diameter is largely a matter of judgment. Their selection as to length will depend upon the thickness of the material through which the screw is to pass and the length of thread or hold that may be obtained in the adjacent piece of wood.

When there is no reason for doing otherwise, always pass the screw through the material of the lesser thickness, and screw it into the thicker. The threads of a screw driven parallel to the direction of the grain of wood cut the fiber of the wood. For this reason, screws do not have the withdrawal resistance that they would have if driven across the grain. Screws entering end grain wood should be screwed into the wood the full length of the threaded portion (see Fig. 207, page 185).

When two or more screws are used in the same locality, they should be so placed as to be out of the line of the same fiber of wood. Place screws as far apart as the work will permit.

When the thickness of the material will permit, the threaded portion of screws of 1¾ inches or less in length should be screwed into the wood. For screws of 2 or more inches in length, three-fourths of the threaded portion of the screw will usually be found sufficient. If the thickness of the holding material will not permit these proportions, the diameter of the screw should be increased. Using a screw of a larger diameter will increase the withdrawal resistance.

Note: When fastening two pieces of wood together with a wood screw, always bore the hole in the top piece large enough to allow the screw to pass through freely.

The insertion of a screw into short grain wood or near an edge is very likely to result in the splitting of the piece. To avoid this trouble, bore a hole (pilot hole) of about the same size as that of the root diameter of the thread of the screw. The root or core diameter of the thread is the diameter of the

screw at the bottom of the thread. Bore a pilot hole for screws inserted into hardwood. Forcing a screw (especially small screws) once it is seated will be likely to cause the thread to strip the fiber of the wood and impair the withdrawal resistance. Applying a little soap to the thread of a screw will aid in its driving.

The bit brace or brace, as shown in Fig. 60, is used for boring, drilling, and countersinking and for driving and removing

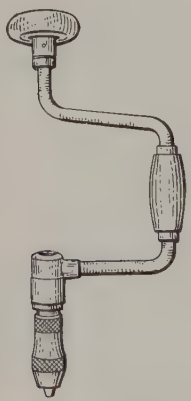


FIG. 60.—The bit brace, used for holding square-shank bits.

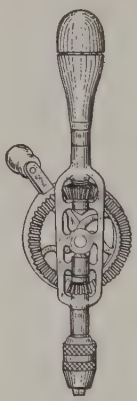


FIG. 61.—The hand drill, used for holding straight-shank bits.

FIG. 62.—A countersink, used to set flathead screws below surface of the wood.

screws. The size of a brace is determined by the diameter of the circle (sweep) described by the throw of the crank.

The hand drill, as shown in Fig. 61, is also used for boring holes for screws. The chuck is made to accommodate straight-shank bits or drills. Twist bits are used principally for boring holes for screws.

The Countersink.—To set a flathead screw below the surface of the wood, the end of the hole requires a conical enlargement or is countersunk. This is done with a countersink, as shown in Fig. 62. (See Counterbore, page 341.)

The Screw Driver.—It is very important that the point of the blade be so shaped (of parallel thickness) that it correctly fits the slot of the screw. If the point of the blade be ground wedge-shaped, the blade will tend to come out of the slot when turned. A brace screw drive is one that is held in a brace.

Keep the screw driver in alignment with the axis of the screw and exert sufficient pressure to keep the point in the slot. A screw driver should never be used for any other purpose than that intended.

Fillets.—Fillets are concave connecting or corner pieces used at the intersection of surfaces. Although the avoidance of sharp inside corners adds greatly to the appearance of a casting, the real benefit derived from the use of fillets is the added strength given to the casting. The filleting of these corners also eliminates sharp edges of sand, which are likely

FIG. 63.—Fillet iron used for rubbing leather or wax fillets into place.

to be loosened by the rapping of the pattern and are apt to fall into the mold cavity.

Wax Fillets.—Wax fillets are made of wax that has been preshaped and is ready to be applied. It is extensively used for the filleting of the corners of small patterns, for the closing of nail holes, and like indentations.

Fillet Cement.—A waterproof preparation used for affixing fillets in place.

Fillet Iron.—A fillet iron, as shown in Fig. 63, consists of a rod with spherical ends that are of different diameters. They are made in various sizes and combinations.

When a fillet iron is used for wax, it is to be heated just enough to make the wax impressible but not enough to melt it. Wax fillet is worked into place after a pattern surface has received the first coating of shellac. A cloth slightly moistened with gasoline will remove any surplus wax that may remain along the edges of the formed fillet.

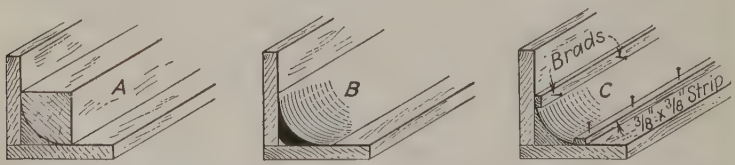
Leather Fillets.—Of the many kinds of material from which fillet stock is made, leather is recognized as giving the best

result. The pliability of leather makes this kind of fillet the most approved, since it readily conforms to irregular shapes. Added pliability is obtained by moistening the face of the fillet.

The method of procedure in affixing leather fillets is to cut the fillet stock to the necessary lengths, then place the fillet face down upon a board, and apply the cement or glue. It is then laid in position and rubbed into place by means of a fillet iron, as shown in Fig. 63. Immediately remove with a damp cloth any surplus glue squeezed out along the edges.

Leather fillet stock ranges in size from $\frac{1}{16}$- to 1-inch radius. For the ordinary run of small machine castings, $\frac{1}{8}$-, $\frac{1}{4}$-, and $\frac{3}{8}$-inch fillets are chiefly used.

Alterations on patterns frequently necessitate that leather or wood fillets be affixed to shellacked surfaces. In the absence of fillet cement this may be done with shellac. To do so, the back of the fillet material is to be given a coating of shellac and also the surfaces of the corner into which it is to be set. If thin shellac is used, then several coats should be applied and allowed to become sticky before rubbing the fillet into place.



A struck fillet is one that is dressed out of the solid wood or from a rectangular strip glued in place as shown at A.

A planted fillet is one that is shaped separately and then applied or affixed as shown at B.

A method of holding down the thin edges of large planted wood fillets while the glue is drying is shown at C.

Pressed is the term generally applied to wax fillets.

PATTERN 4

SURFACE PLATE

Features presented:

The names of the parts or members of a casting
Requirements of a casting that determine the molding position of the pattern
Coping out
Draft allowance on coped surfaces
Built-up patterns
The butt joint
Glue
Wire brads
The trimmer
Leather fillets
Beeswax
Pattern letters and figures

Figure 64 is the drawing of a cast-iron surface plate.

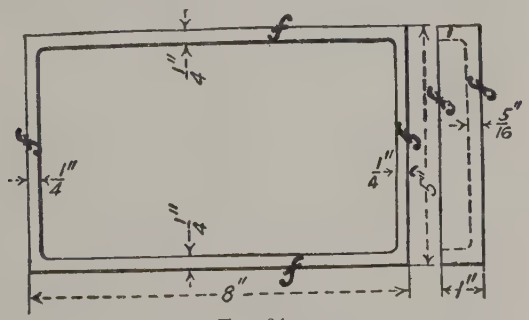


FIG. 64.

There are certain more or less well-defined names applied to the parts or members that go to make up a casting. For instance, a wheel is made up of a hub, the arms or spokes, and

the rim. The surface plate is made up of two members, a web and a flange.

The shape of the casting would suggest that the flange side of the pattern be molded in the drag, but the following reason shows why the pattern is molded in the reverse position.

Any slag, sand, or gas, trapped in the molten metal, rises to the top, giving a coarse and poorer grain to the casting at this point. Iron is more dense and free from impurities at the bottom of the mold. It is very important that the metal in the flat side of a surface plate be dense and free from impurities. Therefore, the flat side of the pattern is molded in the drag or at the bottom of the mold.

The inside surfaces of the flange of the casting are formed by the sand of the cope extending below the parting of the mold, as indicated by *C* in Fig. 65. When the sand of the cope extends downward and takes the impression of the pattern, as in this case, it is said to be coped out.

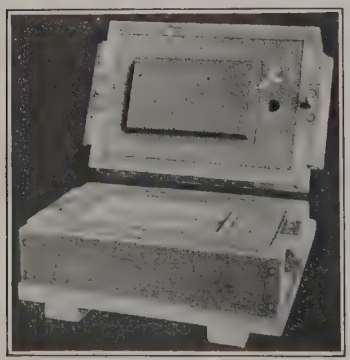


FIG. 65.—The surface-plate mold. The pattern is shown in place.

A surface of a pattern that lies vertical to the parting of the mold and is to be coped must be given excess draft. Excess draft is to facilitate the lifting out of the projecting body of sand. Allow $\frac{1}{16}$-inch draft to each inch of depth upon such surfaces, unless otherwise instructed.

When patterns assume such form and proportion that it would not be practicable to work them out of one piece of wood, they are built up, the joints between the adjacent pieces of wood depending upon glue and brads to hold them together.

The butt joint is the most common joint used in pattern construction, the adjoining pieces of wood being placed or butted together and secured with glue, brads, or screws. The

butt joint is used in the construction of the surface plate pattern.

Figure 66*A* illustrates the surface plate pattern in course of construction. The web, as indicated by *A*, is the flat portion

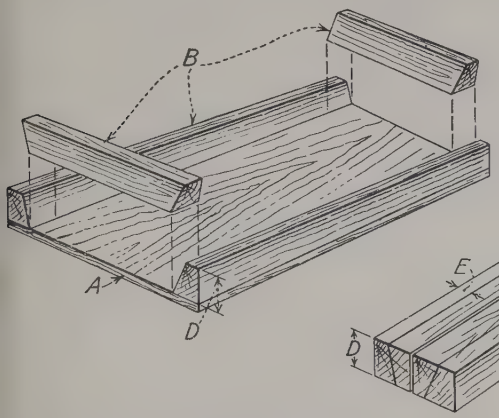


FIG. 66*A*.—The surface plate pattern in course of construction.

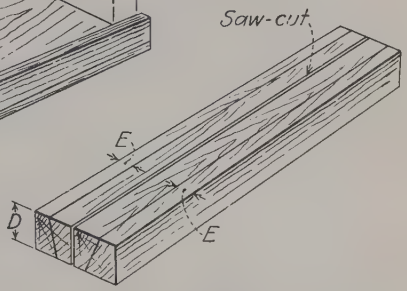


FIG. 66*B*.—Flange stock in process of shaping.

of the casting. The flange is indicated by *B*; it is the projection about the outer edge of the web.

Stock required: $\frac{9}{16} \times 5\frac{1}{2} \times 8\frac{3}{4}$ inches Web
$\frac{7}{8} \times 1\frac{3}{8} \times 13\frac{1}{2}$ inches Flange

ORDER OF OPERATIONS

1. Note the location of the finish marks; consider how this addition will affect the thickness of the members; then proceed to dress the web material to thickness, width, and length.

Two pieces of flange stock are made from one piece of material, as shown in Fig. 66*B*. One of these pieces makes one side and one end flange.

2. Dress the flange material to required thickness *D*, Fig. 66*A*; then square each edge. Note how the addition of finish allowance will increase the height and thickness of the flange.

3. From each edge, gage upon one face the thickness *E* of flange; add $\frac{1}{16}$-inch draft allowance to *E*, and gage this thickness on the opposite face.

4. Separate the material along the middle of its width, and plane the flange stock to its diminishing thickness.

5. Attach the flange material, as shown in Fig. 66*A*, along the width of the web with glue and three 1-inch brads. Glue should always be used in attaching pattern parts.

The end flanges are shown above the surface of the web to which they are to be attached with glue and two 1-inch brads. The joints between the side and end flanges are to be reinforced with one 1¼-inch brad.

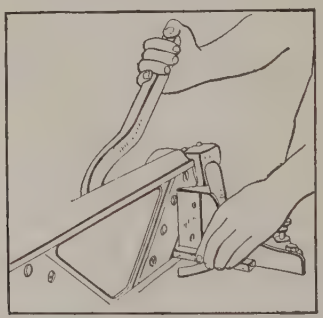


Fig. 67.—Dressing the flange stock to length upon the trimmer.

6. Hold the flange material for the ends in its correct relation to the web member, and with a sharp pencil trace their lengths upon the material.

7. Saw the pieces to their exact traced outline, or trim them to length with a trimmer. (See Disk sander, page 89.)

The Trimmer.—The trimmer, as shown in Fig. 67, is used for dressing or trimming end grain wood.

8. Draft the edge surfaces of the pattern. Refer to the illustration of the pattern in mold (Fig. 65).

9. Fillet the corners of the pattern; ⅛-inch beeswax or leather fillet will be used.

PATTERN LETTERS

Pattern letters and figures as illustrated in Figs. 68*A* and 68*B* are affixed to patterns primarily for the identification of the casting. Those shown at *A* are embossed on aluminum

tape. Those shown at *B* are cast of an alloy and are easily bent to conform to curved surfaces. They are fastened by means of shellac or shellac and small brads.

Pattern surfaces upon which letters are to be placed should be finished with the desired number of coatings of shellac and the letters subsequently affixed.

The letters should first be arranged dry for position and their spacing marked. A coating of shellac is then applied to the back of the letters and also to the surface to which they are to be fastened. When the shellac has become quite

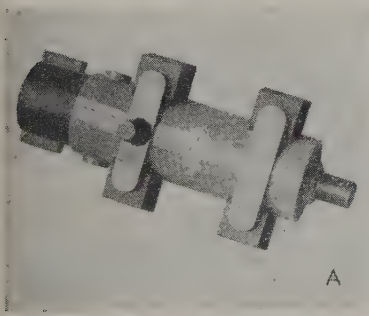


FIG. 68*A*.—Pattern letters embossed on aluminum tape.

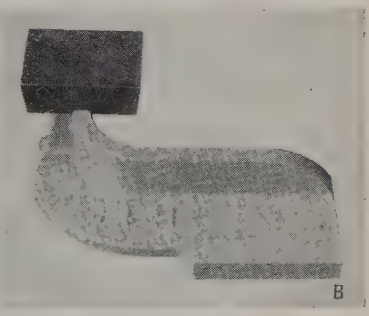


FIG. 68*B*.—Pattern letters cast of a soft alloy.

sticky, the letters are returned to position and adjusted.

Never attempt to use brads until the shellac has become thoroughly dried and then only after holes in the letters have been made with an awl or drill to receive the brads.

Pattern letters and figures with cast brads or spurs can be obtained at a small additional cost.

QUESTIONS

1. How is the size of auger bits specified?
2. What is an expansion bit?
3. What part of an auger bit is the shank?
4. Why is a bit file especially adapted to filing auger bits?
5. Why should the lip of an auger bit never be filed on the underside?
6. Why should only the inside of the spur be filed?
7. How should any roughness on the outside of the spur be removed?
8. How are the walls of small conical-shaped holes best sandpapered?
9. What is machine finish?
10. What is finish allowance?
11. How does a drawing indicate that the surface of a casting is required to be finished?
12. What amount of finish allowance is usually provided upon the surface of cast iron?
13. How are small interior concave surfaces best sandpapered?
14. What are the names of the members which go to make up the surface plate?
15. Why should the face of the surface plate be cast downward or at the bottom of the mold?
16. What is understood by coping out?
17. Why should the surface of a pattern that lies vertical to the parting and is coped be given excess draft?
18. Describe a butt joint.
19. What is used to affix fillets to shellacked surfaces?
20. What advantage have wood screws over nails?
21. Why is it that a wood screw driven in the direction of the grain of wood will not have the withdrawal resistance it has when driven across the grain?
22. What may be used to remove the surplus wax along the edges of fillets?
23. What is the important feature of the point of a screw-driver blade?
24. How is the size of flathead screws specified?
25. What is to be understood by the root or core diameter of the thread of a screw?
26. What may be applied to the thread of a screw to aid its driving?
27. What is likely to happen if force is applied to a screw once it is seated?
28. Why may the contraction on some small patterns be disregarded?
29. What are embossed pattern letters or figures?

PATTERN 5

CLAMP

Features presented:

Vertical dry-sand core
Core print
The bevel
The protractor
The firmer gouge
Shellacking core prints
Marking the location of the core on the pattern when the core comes just to the surface of the casting

Figure 69 is the drawing of a cast-iron clamp.

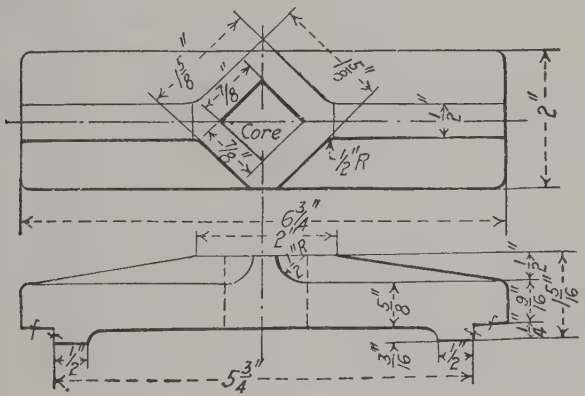


Fig. 69.

The pattern for the clamp is shown in Fig. 70. The casting is composed of the plate *A*, a rectangular pad *B*, and the two ribs *C*. A rectangular hole is to pass through the casting. This requires the application of a dry-sand core.

Cores.—A core is shown in the illustration of the washer mold (Fig. 51). The core indicated by *A* is the conical body

of sand delivered by the hole in the pattern. It is called a *green-sand core*, because it is made of green (damp) sand.

The shape of green-sand bodies is retained only by reason of the dampness; when comparatively small they are not dependable. Therefore the size and shape of the core and metal thickness through which a vertical green-sand core is to pass will determine its application.

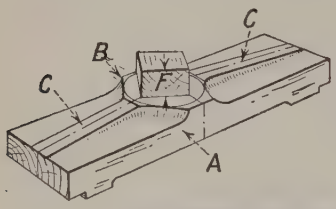


FIG. 70.—The pattern for the clamp.

The following is a safe rule to apply to a vertical green-sand core: If the core is round, the diameter is to equal or exceed the metal thickness through which the core is to pass. If the core is rectangular, the shortest distance across the flats is to equal or exceed the metal thickness.

When green-sand cores become impracticable, dry-sand cores are introduced into the mold. Dry-sand cores, as previously explained on page 32, are made independent of the pattern. They are shaped in forms called *core boxes* (Fig. 77). The stability of dry-sand cores is due to the mixture of sand used (core sand), which requires the core to be placed in an oven and thoroughly dried.

The metal thickness of the clamp through which the core will pass is $1\frac{1}{8}$ inches. The dimension across the flats of the core is $\frac{7}{8}$ inch. The distance across the flats being less than the metal thickness, a dry-sand core is used.

Figure 71 shows the clamp mold with the vertical dry-sand core in place, which forms the rectangular opening through the casting. In order to show the core in place, a part of the mold has been cut away (sectional view shown). Note how the parting of the mold has been arranged to conform to the irregularity of the cope surface of the pattern.

To receive and secure the core in its correct position in the mold, a depression or seat is formed, as at *D*. This seat is formed by the projection upon the pattern at *F* (Fig. 70), called a *core print*.

Core prints should be of sufficient size not only to give a suitable support for the core but to permit easy escape of core gases. This is particularly important in cores practically surrounded by metal, where insufficient means of escape for the core gas developed in the mold may impair the casting.

Stock required: $1\frac{1}{2} \times 2\frac{1}{4} \times 7\frac{1}{4}$ inches Body
$\frac{3}{4} \times 1\frac{1}{2} \times 2$ inches Core print

ORDER OF OPERATIONS

1. Dress material to thickness, length, and width of pattern; then locate the center lines.

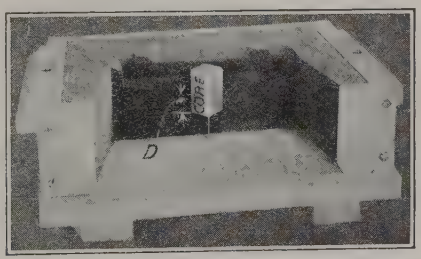


FIG. 71.—Sectional view of the drag part of the mold for the clamp showing the dry-sand core in place that is to form the hole through the casting.

2. Upon the surface selected for the drag face of the pattern, lay out the rectangular outline of the pad *B* and the hole to be cored.

To lay out the square outline of either the pad or the cored hole, scribe a circumference, the diameter of which is equal to the distance across the flats; then circumscribe a square. Scribe these tangent lines with the aid of a bevel set to 45 degrees.

The Bevel.—The bevel consists of a stock with a slotted blade that can be set and locked at any angle. An angle is obtained from a protractor with a bevel, as shown in Fig. 72*A*.

Bevel Protractor.—One type of bevel protractor is illustrated in Fig. 72*B*. It consists of an adjustable rule, held firmly at any point by a thumb nut. The rule passes through a revolving turret that is graduated in degrees from 0 to 90,

both right and left, and that can be accurately adjusted to show any angle.

Note: Before laying out the cope or side views, consider how the addition of the finish allowance will affect the dimensions of the pattern.

3. Upon the face of the material that will be the cope surface, lay out this view of the pattern.

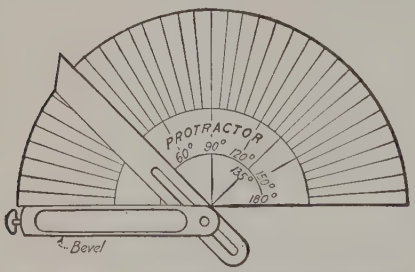


FIG. 72*A*.—Obtaining an angle from a protractor with a bevel.

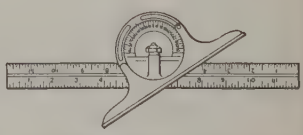


FIG. 72*B*.—Bevel protractor.

4. Upon each edge of the material, lay out the side views of the pattern; then dress the work to this outline.

5. Gage the thickness of the ribs; then dress the pad *B* and the ribs *C* to shape with a firmer gouge, as shown in Fig. 73.

The Firmer Gouge.—The firmer gouge is used in performing this operation. It is commonly called an *outside ground gouge*, because the bevel of the cutting edge is ground on the convex face of the blade. Its action is that of digging. It is used

FIG. 73.—A firmer gouge.

to dress out filleted corners and surfaces that cannot be shaped with a paring gouge. Figure 74 illustrates the manner of holding a firmer gouge. Pressure is exerted upon the handle of the gouge with the right hand. The gouge is controlled by firmly gripping the blade with the left hand. To produce a shearing cut, slightly oscillate the gouge as it is moved forward. For convenience, the work is held in a hand screw.

The hand screw is secured in the vise. For grinding and whetting a firmer gouge, see Turning Gouge, page 185.

6. Make the core print. For the dimension *F* (Fig. 70), refer to column *F* of the table of core-print proportions, page 81. The core print is sandpapered before it is attached. Small flat-edged surfaces like those of the core print are more easily and accurately sandpapered if the sandpaper is held flat upon the surface of the bench with the thumb and second finger. The work is rubbed upon the sandpaper.

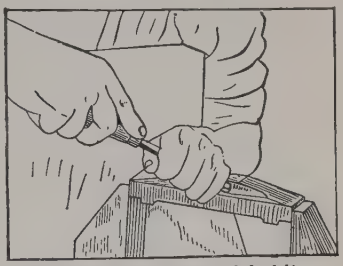


FIG. 74.—Position of holding a firmer gouge. Note how the work is held in a hand screw.

7. Attach the core print.

Apply a small amount of glue to the core print, and rub the core print upon the surface to which it is attached. Allow the glue to set for 20 minutes; then reinforce the joint with two 1¼-inch brads. Bore a pilot hole for the brads.

The fillets connecting the surfaces of the ribs and plate are best sandpapered by using the paper over the ball of the thumb.

8. With sandpaper, break or round the sharp corners of the pattern to about a $\frac{1}{16}$-inch radius. This is never to apply to the corners of core prints or to surfaces of a pattern, if these surfaces of the casting require the operation of machine finish.

COLORING CORE PRINTS AND CORE OUTLINES

In order that the core-print portion of a pattern may be distinguished from the body of the pattern, two different colors of shellac are used. For instance, if yellow is the color applied to the body of the pattern, the core print may be black; or, if desired, the color scheme may be reversed.

The same marking is used on the surface of a pattern to indicate the shape and the location of a core print or a core that just cuts through to the exterior surface of the casting.

This feature is referred to as *the core cuts through.* The core that forms the hole in the clamp cuts through the surface of the casting that is toward the cope. It is to be so indicated on the pattern.

In applying colored shellac to core prints and outlines, it is advisable to finish the entire pattern with the body color. When it has thoroughly dried, then apply the colored shellac to the core-print surfaces and outlines.

Outlining the shape of the core upon the parting surface of the pattern will indicate the metal distribution of the casting at this section and will thus serve as a guide for the molder when setting the core.

DOWEL PINS

Many patterns and core boxes are so arranged that they separate or come apart at a certain point. The core box for the clamp pattern is arranged in this manner. This feature is usually referred to as the pattern of core box being parted.

To register the parts correctly and hold them in their proper relation, dowels or dowel pins are used.

Metal dowels are more durable and are not affected by moisture and therefore are superior to all others. However, the birch or maple dowel rod, on account of its cheapness and the ease with which it may be applied, continues largely to be used. Dowel rods, from $\frac{3}{16}$ to 1 inch in diameter and 3 feet long, may be purchased from any supply house.

The dowels, or dowel pins, are inserted in one-half of the box, and their pointed ends are made to project in order that they may enter holes in the opposite half. The point of a dowel should be so shaped as to prevent any looseness between the two parts but yet allow their instant release or separation. The point proportions for wood dowels, as shown in Fig. 75, have been found to be satisfactory. Make the length A equal to the diameter of the dowel stock. Make dimension B one-fourth of A and C equal to one-half of A. This taper may be made with a chisel but is more easily done on the disk sander

(Fig. 84). Dress the point of a dowel pin to shape before setting it in place.

The size and shape of the work should determine the diameter of dowel to be used. Dowels are more effective if placed as far apart as the work will permit. The common practice of inserting wood dowels, as shown in Fig. 75, is to locate their position upon the parting surface. Holes are then bored through this half of the material. The two halves are now securely clamped together and the holes transferred or continued into the opposite half. Do not bore deeper than is necessary the holes that receive the points of the dowel.

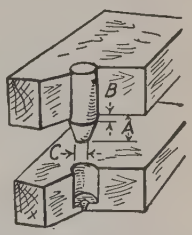


FIG. 75.—Sectional view of a parted member showing wood dowel in place.

The depth of a hole bored with an auger bit may be roughly calculated by counting the number of revolutions from the instant the bit begins to cut. The reason for this is that the lead screw will cause the bit to travel forward at each revolution a distance equal to the lead of its thread. This distance for any size of auger bit can be quickly determined by one or two trials.

To insert brass dowels, as shown in Fig. 76*A*, locate the position of one of the dowels upon the parting surface, place the head of a small brad at this location, and press parts together. The brad head will make an impression in each piece, thus locating the centers of the holes to be bored. Insert the pin first, using the socket upon the pin to protect its point when driving it down into place.

The dowels shown in Fig. 76*B* are called *master dowels*. Holes for these dowels are bored as for the ordinary type, but instead of being driven into place, they are screwed down with a wrench. This permits the withdrawal and the resetting of dowels without loss of alignment to work.

Note: Never attempt to locate the position or set more than one pair of dowels at a time.

Insert one pair of dowels; then place parts together, and register in a like manner the location of the next pair.

If the method of inserting wood dowels is applied to brass dowels, the unoccupied portion of the auger-bit holes is plugged up.

A slight interference (binding) between the pins and sockets may be overcome by placing the material together and striking it a sharp blow with a mallet.

When the shape of a core box or pattern is the same about its center line, the better practice is to offset the dowels so that the misplacement of the parts will be instantly detected. Another way to guard against this frequent error is to use dowels of different diameters.

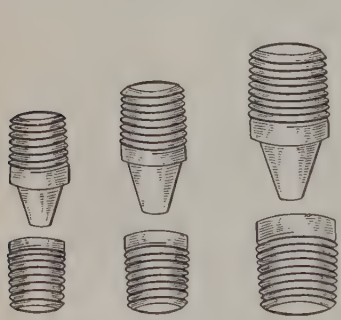


FIG. 76*A*.—Common brass dowel.

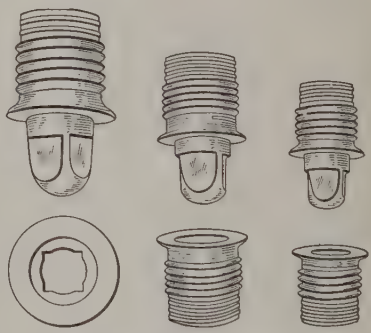


FIG. 76*B*.—Brass master dowel.

CORE BOX FOR THE CLAMP PATTERN

Features presented:

A parted core box

Application of dowel pins

A core box is a form in which a core is shaped.

A parted core box is made up of two or more parts. The core box for the clamp is a parted core box. When small rectangular or cylindrical cores are of such proportions that the core can stand on end while drying, a core box of the form shown in Fig. 77 may be used.

When the length of a core is 3 inches or less, the core cavity may be formed in a direction transverse to the grain of the wood, as shown. Only those external surfaces or dimensions of a core box that give shape to the core are important.

Dimension *A* is the distance across the flats of the core. Dimension *B* is taken from the pattern. It is equal to the metal thickness through which the core is to pass, plus the dimension *F* (Fig. 70) of the core print. Dimensions *C*, *D*, and *E* are unimportant.

Permanency of dimension and form of the core cavity depends upon the surrounding wood; therefore the wood must be so proportioned as to give sufficient strength and durability.

Stock required: $1\frac{1}{4} \times 1\frac{7}{8} \times 7\frac{1}{2}$ inches

Dowel stock: $\frac{1}{4}$ diameter $\times 3\frac{1}{2}$ inches

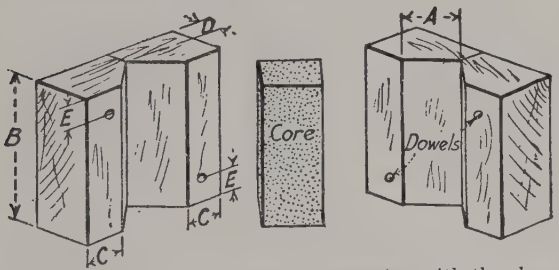


Fig. 77.—The core and core box used in connection with the clamp pattern.

ORDER OF OPERATIONS

1. Prepare the parting surface. Insert the dowels at about the location shown in Fig. 77.

2. Plane one edge true and square to the parting surface.

3. Dress the width of the material to dimension *B*.

4. Locate the center line; then upon both edge surfaces lay out the shape of the core cavity.

5. Scribe lines across the parting surface that represents the diagonal dimension of the core cavity.

6. Saw, and, if necessary, dress the core cavity to shape. If care is exercised, there is no reason why the cavity cannot be sawed to its exact outline upon the band saw and the saw marks removed by careful sandpapering.

Sandpaper the core cavity with the aid of the square corner of a block. The finishing of a core box consists of sandpapering and shellacking the core cavity, the parting

surface, and those exterior surfaces which give shape to the core. The same color of shellac is to be applied to the surfaces of the core box that is applied to the surfaces of the pattern that represents metal. Slightly chamfering the sharp outside edges will prevent the wood from splintering through usage.

Always stamp the number of a pattern or core box in such a surface as will cause the marking to be clearly in view. Do not stamp the number of the pattern in the face surface of a core box or in the surface of a core cavity where it will interfere with the removal of the box from the core.

TABLE OF CORE-PRINT PROPORTIONS

The dimensions of core prints given in the table have been found satisfactory when applied to cores of a round or rectangular cross section, set in a horizontal or vertical position in the mold. The core prints shown in Fig. 78 are for cores set in a vertical position in the mold.

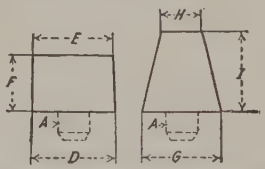


FIG. 78.—A drag and a cope print.

When the print is of circular cross section, it is the usual practice to attach the print to the body of the pattern with a dowel, as shown in broken lines at *A*.

Core prints of a rectangular cross section are attached with glue and brads. When a core print of rectangular cross section is required to be parted from the body of the pattern, it is attached with two dowels.

Column *C* of the table is the diameter of a core if round or the shortest distance across the flats of a core if rectangular.

Columns *D*, *E*, and *F* give the dimensions for drag core prints (prints attached to the drag face of a pattern).

Columns *G*, *H*, and *I* give the dimensions for cope core prints (prints attached to the cope face of a pattern).

Column *K* gives the length of core prints for cores that are set horizontally in the mold.

TABLE OF CORE-PRINT PROPORTIONS

C	*D*	*E*	*F*	*G*	*H*	*I*	*K*
1/2	17/32	1/2	1/2	1/2	1/4	1/2	1/2
9/16	19/32	9/16	1/2	9/16	9/32	9/16	9/16
5/8	21/32	5/8	1/2	5/8	5/16	5/8	5/8
11/16	23/32	11/16	1/2	11/16	11/32	11/16	11/16
3/4	25/32	3/4	1/2	3/4	3/8	3/4	3/4
13/16	27/32	13/16	1/2	13/16	13/32	13/16	13/16
7/8	29/32	7/8	5/8	7/8	7/16	7/8	7/8
15/16	31/32	15/16	5/8	15/16	15/32	15/16	7/8
1	1 1/32	1	3/4	1	1/2	1	7/8
1 1/16	1 3/32	1 1/16	3/4	1 1/16	17/32	1 1/16	7/8
1 1/8	1 5/32	1 1/8	3/4	1 1/8	9/16	1 1/8	7/8
1 3/16	1 7/32	1 3/16	3/4	1 3/16	19/32	1 3/16	7/8
1 1/4	1 9/32	1 1/4	7/8	1 1/4	5/8	1 1/4	7/8
1 5/16	1 11/32	1 5/16	7/8	1 5/16	21/32	1 5/16	1
1 3/8	1 13/32	1 3/8	7/8	1 3/8	11/16	1 3/8	1
1 7/16	1 15/32	1 7/16	7/8	1 7/16	23/32	1 7/16	1
1 1/2	1 17/32	1 1/2	1	1 1/2	3/4	1 1/2	1
1 9/16	1 19/32	1 9/16	1	1 9/16	13/16	1 1/2	1
1 5/8	1 21/32	1 5/8	1	1 5/8	7/8	1 1/2	1
1 11/16	1 23/32	1 11/16	1	1 11/16	15/16	1 1/2	1
1 3/4	1 25/32	1 3/4	1	1 3/4	1	1 1/2	1
1 13/16	1 27/32	1 13/16	1	1 13/16	1 1/16	1 1/2	1 1/8
1 7/8	1 29/32	1 7/8	1	1 7/8	1 1/8	1 1/2	1 1/8
1 15/16	1 31/32	1 15/16	1	1 15/16	1 3/16	1 1/2	1 1/8
2	2 1/32	2	1	2	1 1/4	1 1/2	1 1/8
2 1/4	2 9/32	2 1/4	1	2 1/4	1 1/2	1 1/2	1 1/8
2 1/2	2 17/32	2 1/2	1	2 1/2	1 3/4	1 1/2	1 1/8
3	3 1/32	3	1	3	2	1 1/2	1 1/8

QUESTIONS

1. From what source is organic glue obtained? Synthetic glue?
2. Describe how glue is prepared for use.
3. Describe the arrangement of a kettle for heating glue.
4. What are the essentials of a good glue joint?
5. What is understood by sizing as applied to a glue joint?
6. How is the size of wire brads specified?
7. What is understood by toeing a brad?
8. How should a brad be driven in end grain wood to obtain the greatest withdrawal resistance?
9. When two or more brads are used in the same locality, how should they be placed?
10. How may a brad be inserted through a fragile piece of material without danger of splitting it?
11. What is a nail set?
12. For what purpose is the trimmer used?
13. Why are the sharp inside corners of patterns filleted?
14. What kind of fillet material is recognized as giving the best result?
15. What is the procedure followed in affixing leather fillet?
16. What is a struck fillet? A planted fillet?
17. What is a dry-sand core?

Reminders

Never use machine tools or appliances until thorough instructions have been given as to their use and care.

Never wear loose clothing when operating machinery. The sleeves of clothing should always be rolled up.

Never touch a broken band-saw blade until the lower wheels of the saw have stopped revolving.

Never have a circular saw projecting above the table farther than the work requires.

Never change an electric fuse without shutting off the current.

Never use a machine which is not properly guarded.

Never leave the jointer set with a heavy cut; always adjust the table.

Never discard material which has protruding nail points; it is dangerous.

Acquire habits of caution for your own protection and for that of your shop mate.

Remember that the best safety device *known is a careful person.*

PATTERN 6

LINK

Features presented:
Parted patterns
Contraction for steel

Figure 79 is the drawing of a cast-steel link.

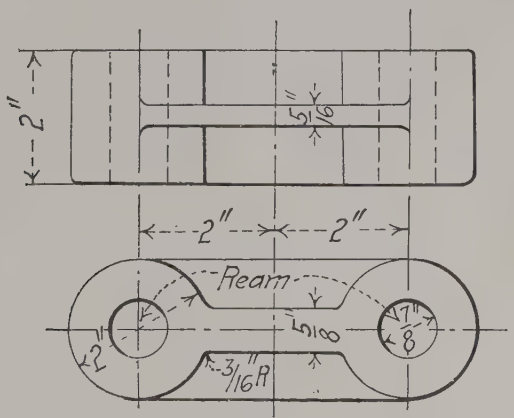


Fig. 79.

Patterns may be regarded as tools to be used in the forming of molds; therefore, every effort should be made in their arrangement to expedite the making of the mold. This may often be accomplished by making the pattern in two or more parts. The parts take their names from the sections of the flasks in which they leave their impressions, as the cope or drag part.

Patterns with webs to which other pattern members are attached or formed upon the opposite surfaces, as in the case of the link, are usually parted along the center of the thick-

ness of the web, as shown in Fig. 81. This applies not only to plain parting surfaces but also to those having an irregular form.

Figure 80*A* illustrates the parting of a mold for a parted link pattern and Fig. 80*B*, the parting for a solid link pattern. No better example is needed to show the advantage of the parted pattern feature. Compare the parting of the mold made by the parted pattern with the parting required to be made for the solid pattern.

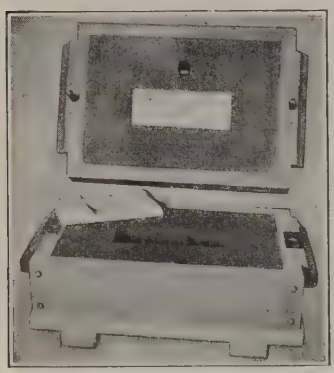


FIG. 80*A*.—The parting surface of a mold made by a parted link pattern.

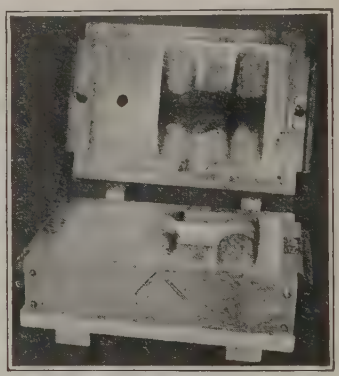


FIG. 80*B*.—The parting surface of a mold required to be made for a solid link pattern.

In the case of the parted pattern, the molding board produces a plain parting; in the case of the solid pattern, it is necessary to make an irregular parting about the pattern, as shown. This extra work adds to the cost of production. An irregular parting adds to the difficulties of lifting off the cope and very frequently results in the defacement of the mold. Further advantage of a parted pattern lies in the fact that the cope half of the pattern is lifted off with the cope; this part of the pattern is then drawn in the usual way.

The cast-steel link is composed of two hubs. The hubs are connected by a member called the web. A rib upon each face of the web further strengthens the casting. The $\frac{7}{8}$-inch holes through the hubs must be reamed. The operation of

drilling precedes that of reaming. The information given with pattern 3, page 55, regarding drilled holes, applies also to reamed holes.

Figure 81 shows the two halves of the pattern in different stages of completion; it also gives the names of the members.

The shape of the link suggests that its pattern be parted through the center of the web or axis of hubs, as shown. Refer to the instruction on contraction of steel, given with page 41.

Stock required: $1\frac{1}{8} \times 2\frac{1}{4} \times 13$ inches Body
$\frac{7}{16} \times \frac{7}{8} \times 8\frac{1}{4}$ inches Ribs

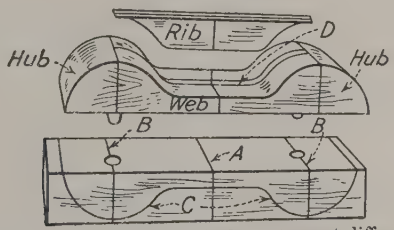


FIG. 81.—The drag and cope part of the link pattern at different stages in their completion.

ORDER OF OPERATIONS

1. Prepare the parting. Make a good joint between the two parts.

2. Place the dowel pins in about the position shown in Fig. 81. Refer to the information on dowel pins, page 77.

If the requirements or the form of casting demand that the pattern be parted, the dowel pins are to be set in the cope part of the pattern. If set in the drag part of the pattern, they will interfere with the placing of the pattern upon the molding board.

3. Dress the material to the required width of pattern.

4. Scribe upon the parting of the drag half, the center lines *A* and *B*; then place the parts together, and transfer these lines to the cope half of the pattern.

5. Scribe upon each edge surface of the material the circumferences of the hubs.

6. From the parting, gage the half thickness of the web, then scribe the fillet *C*, which connects the surface of the web with that of the hubs. Scribe lines across the parting surfaces to represent the over-all length of the pattern.

Attention is called to the struck fillets *C*, so called because these fillets are dressed out during the shaping of the pattern. There would be no advantage in making the line of intersection between the surface of the web and that of the hub a sharp corner and then affixing a planted fillet.

7. Saw and dress the work to outline; then finish this surface with sandpaper. Gage lines as indicated by *D*, which represent the location of the ribs. Figure 81 shows the cope half of the pattern at this stage of completion, ready to receive the rib.

8. Prepare the rib material. Do not plane to width. To obtain the shape of the joint between the hubs and the rib, hold the rib material against the face of the hubs in its correct relation to the surface of the web, and then trace the outline of the hubs upon it.

9. With the gouge, pare the concave joint surface of the ribs to shape.

10. Draft the sides of the ribs, and then glue in place. Do not brad.

11. Allow the glue to set for about 20 minutes; then plane the edge of the ribs tangent to the hubs. Further secure each rib with two 1-inch brads. Drive the brads through the ribs and into the hubs at an angle. Place the brads about ¾ inch from the ends of the ribs.

12. Draft, from the parting, the face of the hubs.

13. Affix the fillets; ⅛-inch beeswax or leather fillet may be used.

14. Break the corners (remove the sharp corners) of the pattern with sandpaper. This does not apply to the corners of the parting surface.

15. Finish the pattern. The parting surfaces of a pattern are given the same shellac finish as the surfaces that give shape to the mold.

PATTERN 7

BRACKET

Features presented:
- Pattern construction
- The rabbet joint
- Disk sanding

Figure 82 is the drawing of a cast-iron bracket. The casting is made up of a *web*, a *flange*, a *boss*, and a *rib*.

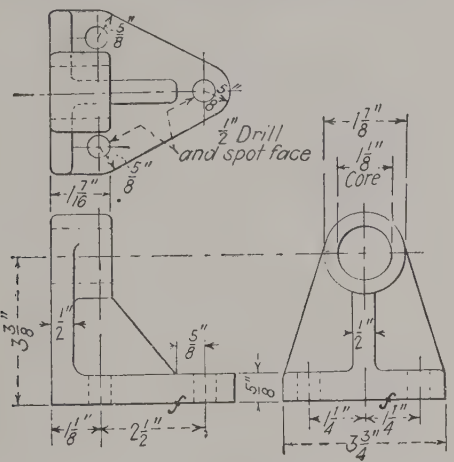


FIG. 82.

The drawing specifies that surfaces about the bolt holes at the back of the flange are to be spot-faced. Spot-facing is the operation of truing up a circular bearing surface. It does not affect the pattern. The hole through the boss is to be cored. Refer to the instruction on cored holes given with pattern 5, page 72.

Figure 83 shows the pattern in course of making; the flange, the web, and the boss have been attached. The chief factor in pattern construction is to arrange the material in such a way as to minimize distortion and to preserve, as far as possible, accuracy of dimension and form. The pattern for the bracket is a good lesson in pattern construction.

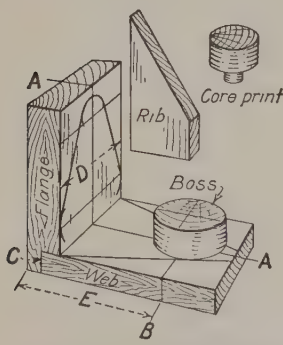


FIG. 83.—The bracket pattern in process of making.

To obtain greater rigidity between two pieces of material that meet at an angle, as the web and the flange, the rabbet joint is used. It consists of forming in the flange a rabbet, as at *C*, into which the web is secured. When two different thicknesses of material are secured together with a rabbet joint, the rabbet is usually cut in the material of the greater thickness.

Stock required:	$\frac{5}{8} \times 4 \times 4\frac{1}{2}$ inches	Web
	$\frac{7}{8} \times 4 \times 4\frac{3}{4}$ inches	Flange
	$\frac{5}{8} \times 2\frac{1}{4} \times 4\frac{1}{4}$ inches	Rib
	$1\frac{1}{16} \times 2\frac{1}{4} \times 2\frac{1}{4}$ inches	Boss

ORDER OF OPERATIONS

1. Dress to thickness the material for the flange and the web, and make the rabbet *C*. This work may be done upon the band saw but is more easily made upon the saw bench, described later and shown in Fig. 100.

2. Draft the inside surface of the flange, and attach the parts together. Drive the brads through the web into the flange material. Test the work for squareness.

3. Dress one edge square with the face surfaces of the flange and the web.

4. Gage the center line *A* along the middle of the width of the material. Lay off the distance *E*, and scribe the center line *B* about the material.

5. Lay out upon the inside surface of the flange, as shown, the shape of this member.

6. Make the boss. The boss may be turned, or it may be sawed and then sanded to shape.

The Disk Sander.—The disk sander, as shown in Fig. 84, is used in sanding to shape flat and convexed surfaces. The sandpaper is affixed to the face *A* of a metal disk. The table *B* is adjustable. It may be set at varying angles to the face *A* of the disk.

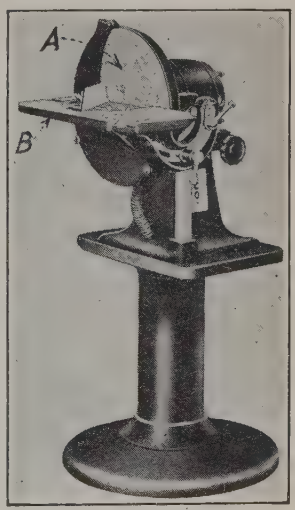


FIG. 84.—The disk sander.

The material for an object that is to be sanded to shape is prepared in the same way as for chisel paring, with this exception: The layout is made upon one face of the material only.

The grain of the wood in the boss, when attached, should lie in the same direction as the grain of the wood in the web.

When a surface of a pattern is formed by two or more thicknesses of material glued together, the grain of the wood should lie in the same direction. End grain wood and cross grain wood are not affected to the same degree by moisture. Therefore, a surface made up of end and cross grain will probably become uneven.

7. Attach the boss. To locate the boss upon the web, scribe a circumference that is the diameter of the boss.

8. Scribe lines as shown, tangent to the boss and intersecting those lines representing the width *D* of the flange, and saw the flange and web to shape. The exact form of these members may be planed and pared to shape, or they may be sanded to shape.

9. Prepare the rib material; fit it into place; then draft the sides, and dress the edge to the required angle. Attach the rib.

10. Round the corners. All corners of patterns are to be rounded to approximately $\frac{1}{16}$-inch radius, unless instructions are otherwise. Do not round the corners of a surface of a pattern if this surface of the casting requires the operation of machine finish.

11. Turn the core print. (See Core-print Turning, page 195.) For core-print proportions, refer to columns *C*, *D*, *E*, *F*, Table of Core Prints (pages 80–81).

12. Bore a $\frac{1}{2}$-inch diameter hole at the center of boss to receive the dowel of core print. Attach the print with glue.

13. Affix the fillets; then finish the pattern.

Core Box for the Bracket Pattern.—In making the core box for the bracket pattern the same order of procedure is followed as for making the core box for the clamp pattern, described on pages 78 and 79.

The brass dowels may be set about $\frac{3}{8}$ inch from the ends and at the middle of the width of the marginal surface. The semicircular cavities of the two halves may be roughed out closely upon the band saw, by making a series of cuts $\frac{1}{16}$ inch apart, at right angles to the parting surface and to within $\frac{1}{32}$ inch of their outline. The outlines are then completed with a paring gouge.

Refer to the method of sandpapering small concave surfaces (Fig. 58, page 57).

Stock required: $1\frac{1}{4} \times 2\frac{1}{2} \times 7\frac{1}{4}$ inches.

Dowels, brass $\frac{1}{4}$ inch.

QUESTIONS

1. What is a core box?
2. What is a core print?
3. For what purpose is the bevel used?
4. What is a protractor?
5. What is the purpose of pattern letters and figures?
6. How may pattern letters and figures be fastened in place?
7. How is the core-print portion of a pattern indicated?
8. Describe two methods of inserting brass dowel pins.
9. How does a firmer gouge differ from a paring gouge?
10. How is a slicing cut produced with a firmer gouge?
11. What is the chief advantage of master dowels?

PATTERN 8

GUIDE

Features presented:

Contraction of brass
Finish allowance for brass
Securing a vertical dry-sand core at both ends
Cope core prints
Avoiding the exposure of end grain wood
Application of dowel pins
Hand screws

Figure 85 is the drawing of a brass guide.

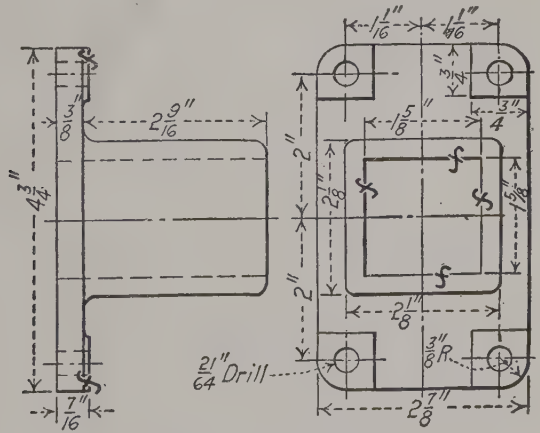


FIG. 85.

If the metal thickness through which a vertical dry-sand core is to pass equals two or more times the shortest distance across the flats if the core is rectangular, or the diameter of the core if it is round, it is a safe practice to secure the core at both ends.

The metal thickness through which the core for the guide passes equals twice the distance across the flats of the core. Therefore the core will be secured at both ends, as illustrated by a sectional view of the mold (Fig. 86). It is done by forming in the parting of the cope a tapered impression, as indicated by *A*, directly above the core-print impression *B* in the drag. The tapered walls of the depression *A* correspond to the taper at the top of the core and are the means of correctly registering the core by the placing on of the cope.

Fig. 86.—Sectional view of the drag part of the mold for the guide.

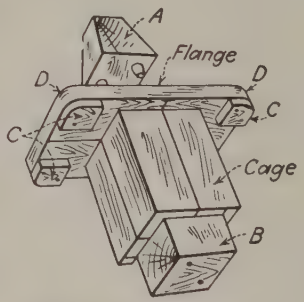


Fig. 87.—The pattern for the guide.

The pattern for the guide is shown in Fig. 87. It is made up of a flange, a rectangular cage or box, and the core prints *A* and *B*. Four pads are attached to the flange, as at *C*.

The cope core print *A* is shown opposite the position it occupies upon the top surface of the flange. Making the cope print loose permits the print to lift off with the cope. It also allows the face of the flange to lie flat upon the moldboard.

Finish marks show that machine finish is required on the internal surfaces of the guide. A frequent mistake made when shaping the core prints is the failure to deduct the finish allowance upon the four walls from the given dimension. One-sixteenth of an inch finish allowance will be allowed on the surface of brass castings.

Refer to the instruction on contraction of metal (page 41).

Hand Screws.—When the material at hand is not of sufficient thickness, two or more pieces of material are glued together. To hold the wood together while the glue is drying, hand screws, as shown in Fig. 88, are used.

The hand screw consists of two jaws and two screws. The contacting surfaces of jaws should always bear evenly against the material, as indicated by *A*, thereby causing the joint surfaces of the material to be forced together. The letters *B* and *C* show how the failure to adjust the jaws correctly results in a poor or open joint, as indicated by *E*. The pressure is

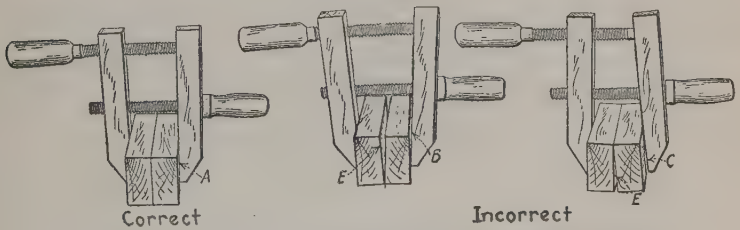


FIG. 88.—Correct and incorrect way of adjusting hand screws.

put upon the jaws by the end screw. The middle screw, which is used for adjusting, simply serves as a fulcrum for the jaws.

Never apply glue to the material before the hand screws have been adjusted to suit the work and are ready for instant use. To make a slight change in the spread of the jaws, loosen the end screw, and adjust the middle screw, as the case may require. To open or close a hand screw, grip the handle of the middle screw in the left hand and the handle of the end screw in the right hand. To open the jaws, revolve the hand screw over toward you, and to close the jaws, revolve it over from you.

Stock required:		
$2\frac{3}{8} \times 2\frac{3}{8} \times 3$ inches		Cage
$\frac{1}{2} \times 3\frac{1}{8} \times 5\frac{1}{4}$ inches		Flange
$1\frac{3}{4} \times 1\frac{3}{4} \times 4$ inches		Core prints
$\frac{1}{4} \times 1 \times 4$ inches		Pads

ORDER OF OPERATIONS

1. Dress the material for the flange to the required thickness, width, and length; then locate the center lines.

2. Dress the material for the cage to the required thickness, width, and length; then locate the center lines.

The grain of wood in the cage is to lie in the direction of its length. End grain wood absorbs moisture more freely than length grain. For this reason, whenever the shape of the pattern permits, the exposure of end grain wood should be avoided.

Accuracy of construction can be attained in no better way than to assemble the parts of a pattern by the exact agreement of their center lines.

3. Locate the cage upon the flange, and attach with glue and brads. Refer to the instruction on the selection of brads and the application of glue to end grain wood (page 59).

4. Dress the material for the core prints to the required thickness, width, and length, and locate the center lines. Do not taper the edge surfaces of the cope print. Refer to the table of core-print proportions (page 81).

5. Locate and bore holes through the cope print for the two dowel pins. The dowels are to be of different diameters ($\frac{3}{16}$ and $\frac{1}{4}$ inch). The use of dowels of different diameters is to prevent the print from being placed in any other position than that intended. Keep dowels as far apart as possible.

6. Locate the cope print in its correct position upon the flange (Fig. 87), and attach temporarily with brads or hand screw; then continue the holes in the flange for the dowel points.

7. Detach the print, and insert the dowels.

8. Upon the top surface of the print, gage the amount the sides are to be tapered; then dress to shape.

9. Dress to shape and sandpaper the drag print; then attach it with glue and brads.

10. The strip of material from which the four pads are made is dressed to the required thickness and width of the pads. It is then cut up into the required lengths and attached.

Upon the surfaces of the pads, scribe arcs representing the outline of the rounded corners of the flange, as at *D* (Fig. 87), and dress the corners to shape.

11. Finish the pattern. One-eighth-inch fillet will be used. The surface covered by a loose core print is to have the same color as the print. Refer to the instructions on shellacking core prints given with pattern 5 (page 75).

CORE BOX FOR THE GUIDE PATTERN

Features presented:

Making a dry-sand core in halves
Core box for a core made in halves
Toeing a nail
Application of draft to the surface of core cavities.

Dry-sand cores are sometimes made in halves and pasted together after having been dried. This is often the practice when a small number of cores is required. The shape of a core will sometimes necessitate this feature. Making the core in halves saves material and time in constructing the core box, and the plane joint surface of the half cores permits them to lie flat upon the core plate while being dried.

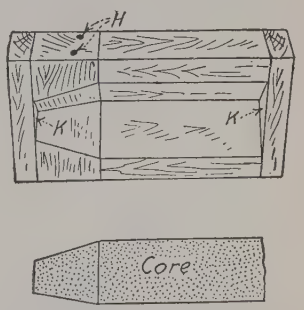


FIG. 89.—One-half of the core for the guide and the core box in which it is formed.

Figure 89 illustrates the core box for the guide and the one-half core formed within it. Two half cores are formed in the box: the cores are then dried and subsequently pasted together.

The surface of a core cavity, that lies parallel to the direction the core box is removed from the core, is to be drafted. The surfaces *K* of the core cavity lie in this direction and therefore are to be given draft. Draft is provided upon these surfaces by slightly slanting toward the bottom of the core cavity the surfaces *J* (Fig. 90).

The separated pieces of material that make up the box are shown in Fig. 90. Dimensions are indicated by letters. *A* is the distance across the flats of the core. *B* is equal to the metal thickness through which the core is to pass, plus the length of the drag core print. *C* and *D* are taken from the cope core print. *E*, *F*, and *G* are unimportant dimensions.

Stock required: $1\frac{5}{8} \times 3\frac{3}{8} \times 4\frac{3}{8}$ inches
$1\frac{5}{8} \times 1\frac{5}{8} \times 3\frac{1}{2}$ inches
$\frac{5}{8} \times 1\frac{5}{8} \times 7$ inches

ORDER OF OPERATIONS

1. True up one face and one edge of the material that is to contain the triangular core cavity; then dress the material to length *B*.

2. Locate a line along the center of the width and across each end.

3. Upon the end surfaces, scribe semicircumferences as shown in broken lines, whose diameters are equal to the distance across the flats of the core.

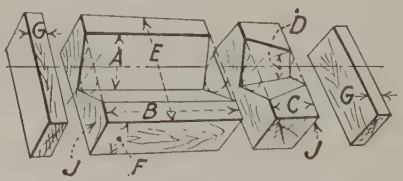


Fig. 90.—The parts of the core box for guide dressed to shape and ready to be attached together.

4. At 45 degrees to the face of the material, scribe lines tangent to the semicircumferences. Gage lines at such a distance apart as is represented by the diagonal dimension of the core cavity.

5. Dress the core cavity to shape.

6. Dress to dimension *C* the material for the core-print portion of the box, and scribe center line.

7. Repeat operations 3 and 4, using for the layout on one surface of the material a semicircumference whose diameter is equal to the distance across the flats of the top of the cope core print.

8. Sandpaper the core cavity with the aid of the square corner of a block.

9. Attach the parts with glue and brads.

Apply the glue to the parts containing the cavity, and rub the joint surfaces together while the face of the pieces are held down upon a flat surface. Allow the glue to set for about 30 minutes; then reinforce the joints with brads. Drive the brads at an inclination to the joint as at *H* (Fig. 89); this is called *toeing a nail.* Provide the draft upon the surfaces *K*, and attach the end pieces.

10. Dress the edge surfaces, and chamfer the corners. Refer to the intructions on finishing core boxes given with pattern 5 (page 79).

THE PLUGGING OF CORE SEATS

Frequently it will be found expedient to plug the seats for small cylindrical cores when the said member of the pattern

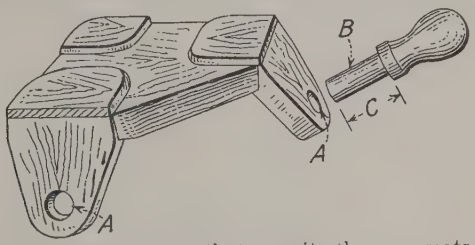


FIG. 91.—A pattern arrangement that permits the core seats to be formed with a plug.

lies at such an angle to the direction of its withdrawal from the sand as to prohibit the use of a simple round core print. This method is therefore adaptable in the case of making the mold of the pattern shown in Fig. 91.

Cored holes of $\frac{3}{4}$-inch diameter are required in the angular ears of the casting and are represented by the auger-bit holes *A*, bored at the required location through the pattern.

The pattern is molded in the usual manner, but before being drawn, the plug *B* is inserted into the holes *A* and forced down into the sand. The withdrawal of the plug leaves impressions into which the cores are set. The length of the cores required is equal to the dimension *C* of the plug.

PATTERN 9

PEDESTAL

Features presented:

Parting pattern
Parted core prints
Finishing the surface of a casting by grinding
Supporting at both ends a core set horizontally in a mold
Cope clearance at the ends of cores set horizontally
Fitting small bosses to oblique surfaces.

Figure 92 is the drawing of a cast-iron pedestal.

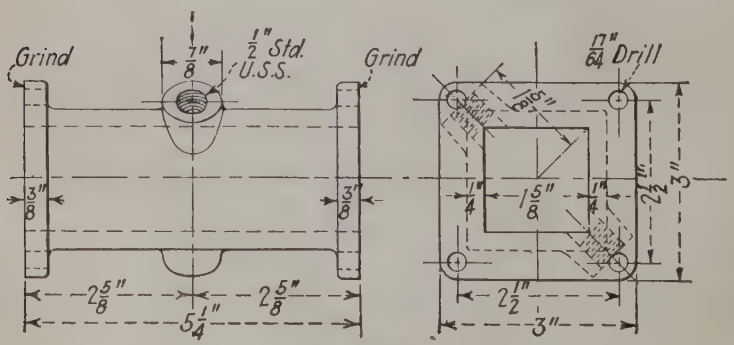


FIG. 92.

The casting consists of two flanges connected by a body, or shell, of a rectangular cross section. Round bosses extend out from diagonal corners of the shell. The drawing specifies that the faces of the flanges are to be ground.

Grind, when applied to a casting, means that a surface is to be finished by the use of an abrasive wheel or disk. Unless the drawing states that an amount of stock is to be allowed for this operation, no attention is given to it by the patternmaker.

For small castings of a rectangular cross section, it is usually good practice to part the pattern diagonally. This arrangement facilitates the drawing of the pattern as well as the setting of the core into the mold.

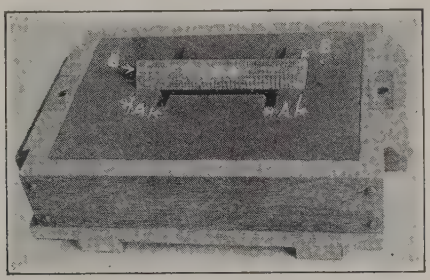


FIG. 93.—Drag part of the mold for the pedestal showing the core in place.

Figure 93 illustrates the drag part of the mold with the core in place. The core is located and held in place by the seats *A*, formed by the core prints extending out from the ends of the pattern.

The ends of the cope half of the prints are made to overhang the drag half, as shown in Fig. 94. This is to give clearance and prevent the cope from touching the end surfaces of the core during the closing of the mold. For small cores, this overhang is to be about $\frac{3}{32}$ inch. No attention is given this overhang feature in making the core box, since the length of the core is made to suit the drag half of the pattern.

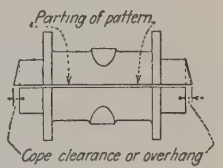


FIG. 94.—The pedestal pattern illustrating how provision (overhang) is made on the end of core print to provide cope clearance.

The triangular-shaped parts that go to make up the drag half of the pattern are shown in Fig. 95.

The shape of the parts for one-half of the pattern is shown laid out upon the material in Fig. 96*A*.

Stock required: $1\frac{5}{8} \times 3\frac{1}{4} \times 10\frac{1}{4}$ inches, body
$\frac{1}{2} \times 2\frac{5}{8} \times 15$ inches, flanges
$1\frac{1}{8} \times 1\frac{5}{8} \times 9$ inches, core prints
$1 \times 1\frac{1}{8} \times 3$ inches, bosses

ORDER OF OPERATIONS

1. Select the material for the body; prepare the parting; then set the dowels (Fig. 96*A*).

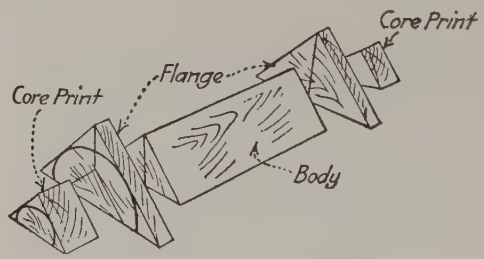


FIG. 95.—Members of the drag part of the pedestal pattern shaped and ready to be attached together.

Note: For the correct assembling of the pattern, each member is to have a well-defined center line scribed about it.

2. Place the parts together, and dress the work to length.

3. Lay out the shape of the body upon the ends; then dress to its rectangular cross section.

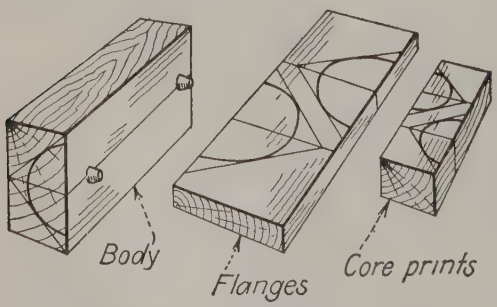


FIG. 96*A*.

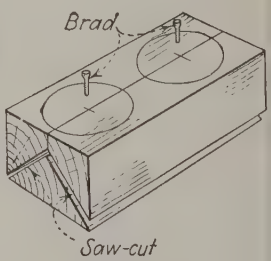


FIG. 96*B*.

FIGS. 96*A* and *B*.—Pattern members in process of shaping.

4. Prepare the material for the flanges and the core prints. A saving of material will result if the shape of these members is laid out upon the wood as shown in Fig. 96*A*.

Allow for the overhang in preparing the material for the prints on the cope half of the pattern.

For the length of the core prints, refer to the Table of Coreprint Proportions (page 81).

The parts of the pattern may be accurately shaped, but unless they are correctly assembled through the alignment of their center lines, the pattern may be worthless.

5. Assemble the drag part of the pattern first. Hold the parting surfaces of the flanges firmly down upon a flat surface when gluing them to the body. Rub the joint surfaces together; do not use hand screws. Allow the glue to set about 30 minutes; then reinforce the joints with brads.

6. Attach the core prints in the same manner as the flanges.

7. Assemble the cope half of the pattern upon the drag half. A piece of paper placed upon the parting of the drag will prevent any surplus glue from affixing the cope to the drag.

8. Shape and attach the bosses. Figure 96*B* illustrates the material from which the bosses are made. Two sawing operations are required in shaping a boss. First the saw cut, as shown, is made; this cut forms the 90-degree joint surface. The parts are then held together with a brad while the bosses are sawed and sanded to their circular form.

9. Finish the pattern, then outline the core on the parting surface of the drag half. See instructions, page 75.

CORE FRAME FOR THE PEDESTAL PATTERN

Features presented:

Core-frame construction
Drag clearance at the ends of the core set horizontally
The dado joint
The router
The saw bench

Cores of rectangular shape are usually formed in a core box or frame, as shown in Fig. 97. The inside dimensions of the frame represent the required dimensions of the core. With the exception of the depth *B*, the outside dimensions of the frame are unimportant. The material from which a core frame is made should be of sufficient thickness *A* to withstand without distortion the ramming in of the sand. For large frames, the thickness *A* will vary somewhat with the depth *B*, but for small-sized frames, as herewith discussed, $\frac{7}{8}$ inch will be strong enough.

When the cross section of the core that is supported at both ends is the same throughout its length, make the length of the core $\frac{1}{16}$ inch less than the distance between the end surfaces of the drag prints. This amount of clearance permits the core to enter the print depressions without end interference.

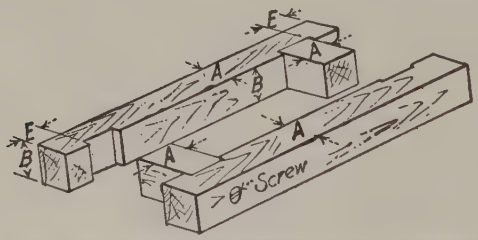


Fig. 97.—Core frame used in connection with the pedestal pattern.

To sustain permanency of form, the ends and side pieces of the frame are secured together with the dado joint. The width of the surface is first sawed to the required depth; the waste is then removed by a series of cuts and the surface finished with the router as shown in Fig. 98.

The Router.—The router is used for smoothing the face of depressed surfaces. Figure 98 illustrates how a router is used

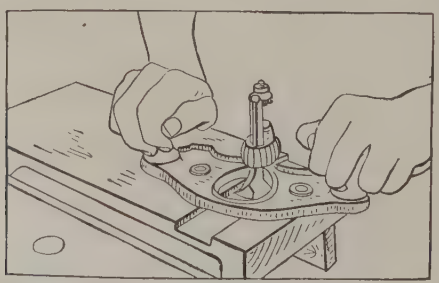


Fig. 98.—Finishing the depressed surface of a dado with a router.

in smoothing the face of the depressed surface of a dado. Do not attempt to take a heavy cut with a router.

Stock required: one piece $1 \times 3\frac{3}{4} \times 13\frac{1}{2}$ inches

ORDER OF OPERATIONS

Figure 99 illustrates how the ends and side pieces of the frame are made from one piece of material.

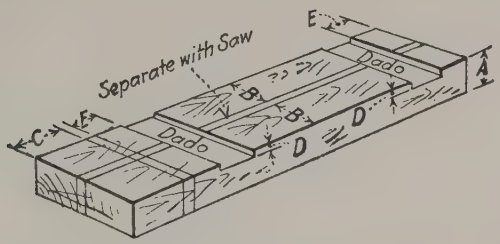


FIG. 99.—The material for the core frame in process of shaping.

1. Prepare the material; dress the ends; then plane to a parallel width. Allow about $\frac{1}{4}$ inch for the separation of the material along the middle of its width.

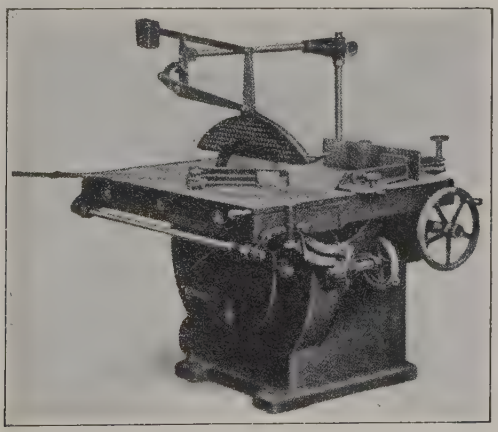


FIG. 100.—Saw bench.

2. From one end of the material, lay off the length dimensions of the side pieces; make dimension E of the side pieces equal to the thickness A.

3. Lay out and dress the dadoes to shape. The depth dimension D of the dadoes will be $\frac{1}{8}$ inch.

4. From the opposite end of the material, lay off the length *C* of the end pieces. The length *C* of the end pieces is equal to the distance across the flats of the core plus two times *D*.

5. Dress end and side pieces to length; then separate along the middle of their width, and dress to dimension *B*.

Each end piece is attached to a side piece with a screw placed at the point shown in Fig. 97.

6. Chamfer the outside corners, $\frac{1}{16}$-inch chamfer. The diagonal corners of the frame are unattached, as shown; this permits the frame to be easily removed from the core.

The Saw Bench.—The universal saw bench, as illustrated in Fig. 100, is a very important machine used in patternwork for ripping, crosscut sawing, and grooving.

Rabbet and dado joints are usually made upon the saw bench.

The universal saw bench is provided with both rip and crosscut saws, either of which may be brought into action by turning a handwheel.

The table may be tilted at any angle from zero to 45 degrees.

QUESTIONS

1. How may the depth of a hole bored with an auger bit be roughly calculated?

2. Why are brass dowel pins superior to wood dowels?

3. Describe a method followed in inserting brass dowels.

4. What is a parted pattern?

5. What advantage is gained by parting the link pattern?

6. Name the members composing the link casting.

7. What is the contraction allowance for steel castings?

8. How should the parting surface of a parted pattern be finished?

9. What rule may be applied to determine the use of a cope core print?

10. Why is the cope core print of the guide pattern tapered?

11. What is the object in making the cope print of the guide pattern loose or parting it from the flange?

12. What contraction allowance is made for brass?

13. What is the usual finish allowance provided upon the surface of brass castings?

14. Explain how the jaws of a hand screw are adjusted to suit a piece of work.

15. Why are dowel pins of different diameters used to attach the cope core print of the guide pattern?

PATTERN 10

PAWL

Features presented:
Countersawing
Fitting bosses to oblique surfaces
Spoke shave

Figure 101 is the drawing of a cast-steel pawl.

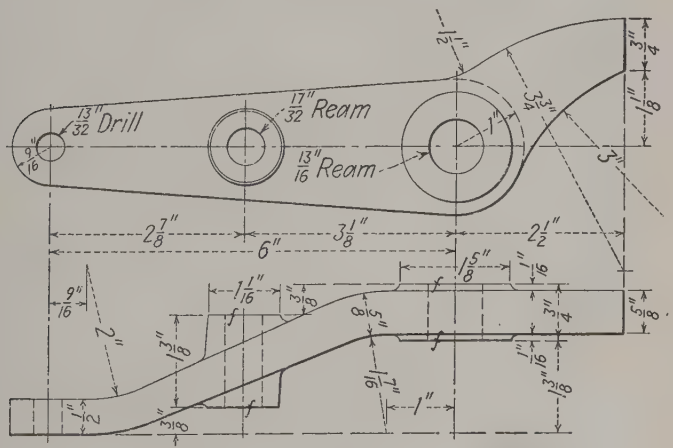


Fig. 101.

Pattern members similar in form to the plate portion of the pawl pattern are usually shaped by what is termed *countersawing*. It is the method of sawing to shape the outline that represents two views of a pattern member from a piece of material of a rectangular cross section. This method of shaping a member will cause an excess amount of waste; however, the time saved will more than compensate for the loss of material.

Stock required:	$2\frac{1}{4}$	× $3\frac{1}{2}$	× $10\frac{1}{4}$	inches	Plate
	$1\frac{1}{4}$	× $1\frac{5}{8}$	× 4	inches	Bosses
	$\frac{1}{4}$	× 2	× 4	inches	Facings

ORDER OF OPERATIONS

1. Dress the material to the required dimension C of the pattern. Make width D of the material about $3\frac{1}{4}$ inches.

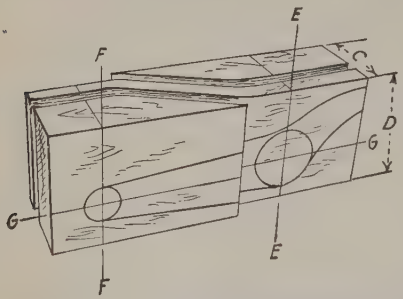


FIG. 102.—The work at the completion of sawing the plate member to its front view.

2. Dress one end, and from this surface lay off and scribe the center lines E and F. Gage the center line G about $1\frac{1}{4}$ inches from one edge of the material.

3. Upon one face of the material, lay out the top view of the plate. Upon one edge of the material, lay out the front view of the plate.

4. Saw the plate to the outline of its front view (Fig. 101). Figure 102 shows the work at the completion of this operation.

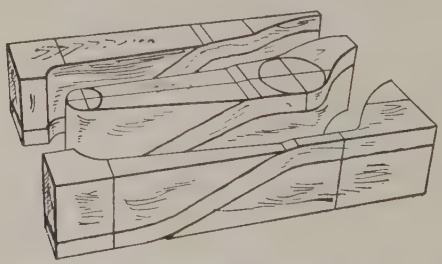


FIG. 103.—The work at the completion of sawing the plate member to its top view.

5. Rescribe upon both faces of the plate the portion of the center lines destroyed by the sawing operation; then brad the parts together.

6. Saw the plate to the outline of its top view. Figure 103 shows the work at the completion of this operation.

7. Dress the surface of the plate with a spoke shave as shown in Fig. 104.

For convenience, the plate is held in a hand screw. The hand screw is secured in a vise.

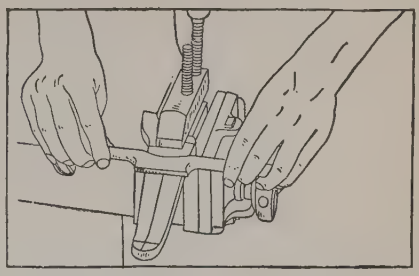


Fig. 104.—Dressing with a spoke shave the plate member of the pawl pattern.

The Spoke Shave.—The spoke shave works on the same principle as a plane. The fact that the guiding surface is very short makes it adaptable to surfaces of a curved nature. The control of the spoke shave depends upon a sensitive touch.

The blade is ground upon a narrow-faced abrasive wheel. It is best whetted on the edge surface of a small oilstone secured in a block, as shown in Fig. 105.

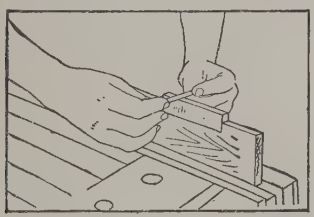


Fig. 105.—Whetting a spoke-shave blade on a narrow oilstone. The oilstone is set into a block.

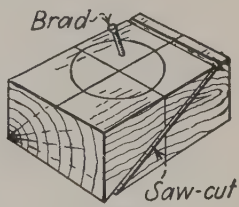


Fig. 106.—Bosses in process of shaping.

It is very important that the face side of the blade be preserved in perfect condition. Do all the grinding and whetting on the beveled side. Never touch the face except to remove the wire edge, and then be careful to hold the face of the blade flat upon the stone.

8. Shape and attach the facings and bosses. Figure 106 illustrates the bosses in course of shaping. Refer to the information on the shaping of bosses given on page 101.

PATTERN 11

SUPPORT

Features presented:

Shaping patterns

Figure 107 is the drawing of a cast-iron support. The casting is composed of a cylindrical-shaped body, a pad, and a clamping lug.

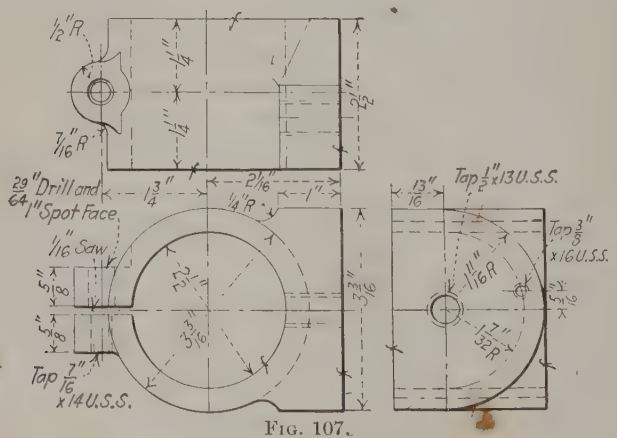


FIG. 107.

The drawing shows a saw cut through the center of the thickness of the lug. The note "$\frac{1}{16}$-inch saw" indicates the thickness of the slitting saw or cutter to be used. It does not affect the pattern.

A tapped hole is required in one-half the thickness of the lug. Tapping is the operation of threading a hole. The operation of drilling precedes that of tapping. The information previously given regarding drilled holes applies also to tapped holes.

The 2½-inch hole through the casting requires finish. Unless otherwise instructed, finished holes in iron castings of 1¼-inch diameter or less will be drilled. Finished holes greater than 1¼-inch diameter will be cored ¼ inch less in diameter than the finished size.

The shape in a great number of small castings makes it more practicable to dress the members of the pattern out of solid wood. The pattern for the table support is a good lesson of this kind. Figure 108 shows the drag and the cope half of the pattern at different stages in the making.

Stock required: $1\frac{3}{4} \times 3 \times 10$ inches Body
$1\frac{1}{4} \times 2\frac{1}{2} \times 10\frac{1}{2}$ inches. Core print

ORDER OF OPERATIONS

1. Prepare the parting and set the dowels.

2. Reduce the material to the width *A* of the pattern; then dress the end surface that is to be the face of the pad.

3. Upon the parting of the drag half of the pattern, scribe the center lines *B*, *C*, and *D*.

4. Transfer the center lines to the cope half; then lay out the side views of the pattern.

5. Dress the work to this shape. The drag half of the pattern is shown at this stage of completion.

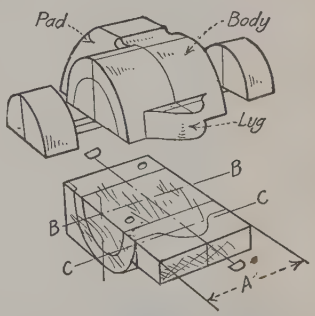


FIG. 108.—The drag and cope part of the support pattern at different stages of completion.

6. Lay out the shape of the lug upon the parting and also upon the faces of the lug.

7. Dress the lug to shape. The cope half of the pattern is shown at this stage of completion.

8. Upon the end surface of the material locate the center of the circular shape of the pad; then scribe this outline.

9. Dress to shape the lateral surface of the pad back to its point of intersection with the cylindrical surface of the body of the pattern.

The core prints are sawed, then pared or sanded to shape. Refer to the instruction on providing clearance at the end of cores, given with pattern 9 (page 99).

CORE BOX FOR THE SUPPORT PATTERN

Features presented:

Shaping semicircular core cavities
Arranging the material for core boxes
Roughing out the core cavity upon circular saw
The core-box plane
The rabbet plane
Testing the accuracy of a semicircular core cavity
Stock required: $1\frac{3}{4} \times 4 \times 11$ inches

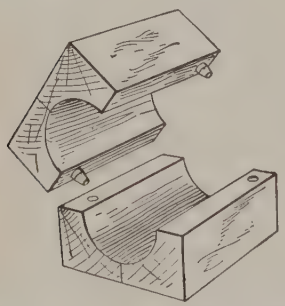


FIG. 109.—Core box used in connection with the support pattern.

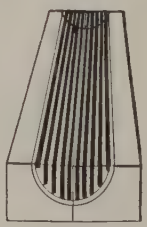


FIG. 110.—The waste material removed by a series of saw cuts.

When cylindrical cores, as required for the table support, are wanted in number, a core box, as illustrated in Fig. 109 is made.

Material of ample length to make both halves of the box is laid out and dressed to shape; it is then sawed and dressed to the required lengths and doweled together as shown.

Semicircular core boxes of $3\frac{1}{2}$ inches or less in diameter are usually worked out of solid material. The greater part of the waste is removed from the core cavity by a series of saw cuts, as shown in Fig. 110. To save material, core boxes between $3\frac{1}{2}$ and 6 inches in diameter are stepped up, as shown in Fig. 111.

The surface of the concavity is then carried to completion with a bent-shank gouge or a core-box plane.

When the surface is to be finished with the gouge, the saw cuts should be made to the line, then used as a guide in completing the surface.

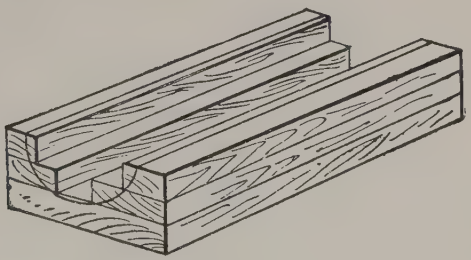


FIG. 111.—Method of stepping up the material for semicircular core boxes.

The Core-box Plane.—When the cavity is to be shaped with a core-box plane, as shown in Fig. 112*A* or 112*B*, allow $\frac{1}{8}$ inch to remain as at *D*, to be removed with this tool.

The core-box plane shown in Fig. 112*A* will dress out core cavities ranging from $\frac{3}{4}$ to 6 inches in diameter. Angular side guides adjusted to suit the width of the material hold the plane in correct position through its length.

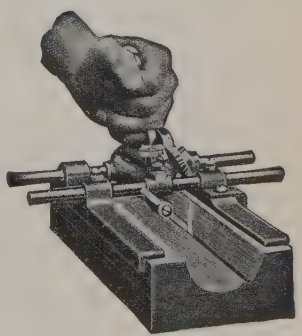


FIG. 112*A*.—Core-box plane with rotating cutter.

Material for boxes to be shaped with a core-box plane should be dressed to a parallel width and the outline of the cavity accurately made upon each end.

The core-box plane shown in Fig. 112*B* is constructed on the principle of a square. The sides are at an angle of 90 degrees to each other.

This core-box plane is not confined to straight semicircular cavities; it may also be used in dressing out cavities of tapered form provided the taper is not too great. In dressing out a cavity of this shape, a greater amount of material must

be removed toward the large diameter of the cavity; otherwise the faces of the plane will not bear evenly upon the edges of the cavity throughout the length of the work.

To start and guide a core-box plane throughout the length of the first cut, a rabbet of $\frac{1}{32}$-inch depth is made as at *E* (Fig. 112*B*). The rabbet may be made upon the saw bench or with a rabbet plane, as shown in Fig. 113. To guide the rabbet plane, a strip is bradded along the line representing the edge of the core cavity.

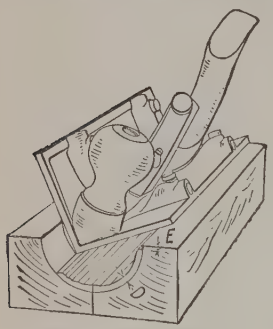


FIG. 112*B*.—Shaping a semicircular core cavity with a V-type core-box plane.

The Rabbet Plane.—The rabbet plane is used for planing rabbets and dadoes. The bit extends to the full width of the face of the plane. This feature makes its application possible into corners up against perpendicular surfaces that are inaccessible to other planes. The size of a rabbet plane is specified by the width of the face in inches.

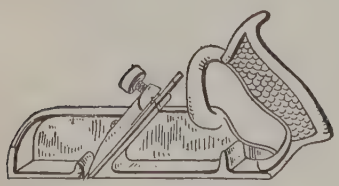


FIG. 113.—The rabbet plane.

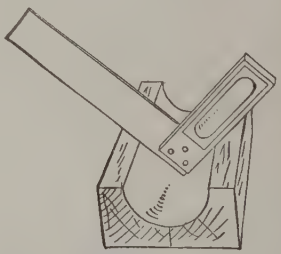


FIG. 114.—Testing with a try square a semicircular core cavity.

The accuracy of a semicircular core cavity may be tested with a square, as shown in Fig. 114. If the two edges of the square rest upon the edges of the core cavity, as shown, the corners of the square should just touch the concave surface at all points. It is upon this principle that the V-type core-box plane is constructed.

A PATTERN LAYOUT

A pattern layout is a full-sized drawing of one or more views of the required casting, to which are added the pattern features. Being made in full size, it brings into view certain features of construction that would be obscure on small-scale drawing. It is used as a direct reference in getting out the material and dimensioning the work.

The drawing should be made as accurately as possible according to the contraction-rule measurements. It should show clearly all pattern features and details of construction.

The surfaces of the casting requiring machine finish should be noted and the amount of finish allowance shown on the layout. To show more clearly the amount provided upon a surface, it may be blackened with lead.

Mistakes are less likely to occur if the layout is made with the contraction rule to the given dimensions and the pattern features and allowances then added.

Do not make a layout unless the pattern is more or less complicated or is of such form that its outline cannot be transferred directly from the drawing. If not required, do not make an entire layout of a pattern but only those views or that portion which will materially assist the work.

The location of drilled holes and other features, which are purely machine-shop operations and to which the pattern-maker gives no consideration, is eliminated from the layout.

The Layout Board.—The board used for making a layout should be perfectly dry and of soft material, preferably white pine. If it exceeds 10 inches in width, it should be battened to keep it straight. It should be planed perfectly smooth and one edge made straight and true. All gaging and squaring of lines should be done from this edge.

The points that have been covered in the information pertaining to the laying out of lines upon wood are to be applied to the layout board.

Do not use a pencil to make a layout, but when the layout is completed, the scribed lines may be further defined with a medium-hard, chisel-pointed pencil.

Never destroy a layout until the pattern has been checked.

Figure 115 is the layout of pattern 12. It is a pattern for the legs of a small bench lathe. Since the shape of the pattern is symmetrical with respect to the center line *A*, a layout of

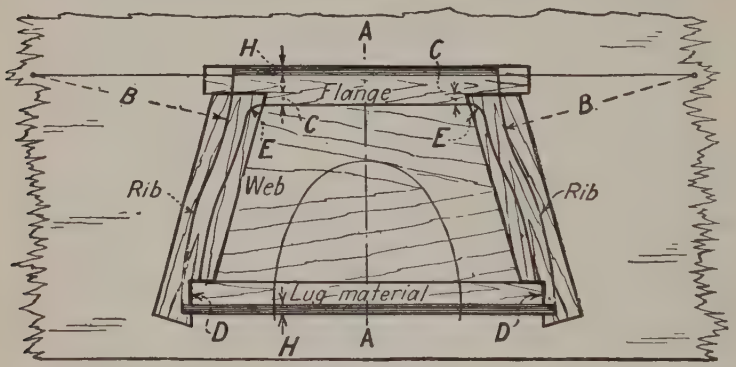


FIG. 115.—The layout of the lathe-leg pattern as it would appear upon the layout board.

one-half of the pattern would be sufficient; however, for the sake of clearness, an entire layout is shown.

By representing, as illustrated, the direction of the grain of the wood in the various pieces, the separate pieces are readily distinguished and the joint lines clearly shown.

The layout in this case is needed to determine the thickness of the material for the ribs, the angle at which it is joined to the flange, the arrangement of the joints between the flange and the ribs, and the joints between the lugs and ribs.

By joining the rib material at an angle, as shown, the maximum strength of construction is obtained, since it causes the shape of the ribs to lie in the direction of the grain of wood. The finish allowance required is indicated by the heavy shaded lines at *H*.

PATTERN 12

LATHE LEG

Features presented:
- A pattern layout
- Pattern construction
- Band-sawing
- Application of a templet

Figure 116 is the drawing of a cast-iron lathe leg.

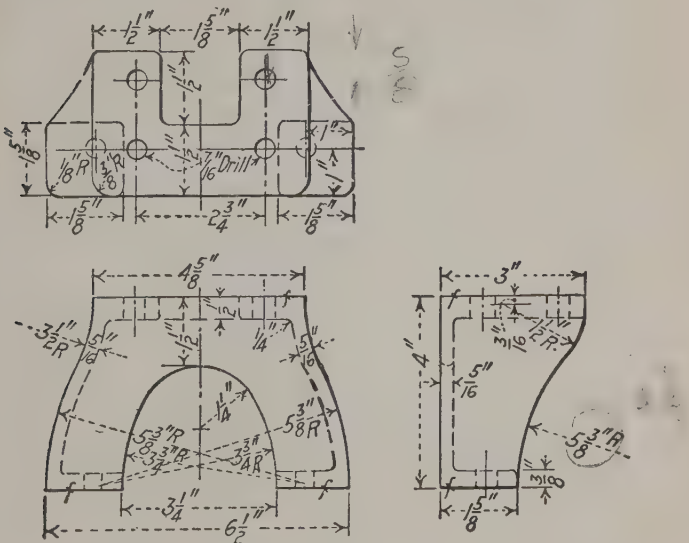


FIG. 116.

The leg casting is made up of a web, a flange, two ribs, and two support lugs, as shown by the layout of the pattern in Fig. 115. The top view of the casting shows that the front corners of the leg begin with a 3/8-inch radius at the top surface and terminate with a 1/8-inch radius at the lug. The 3/8-inch

radius continues for about ¾ inch, then is gradually reduced to ⅛ inch, and continues this radius the balance of the length.

The making of the pattern affords a good lesson in the use of the band saw, for with the exception of rounding the corners, the shaping of the pattern is practically completed upon this machine.

Stock required:		
¾ × 3	× 5½ inches	Flange
1 × 3	× 9 inches	Ribs
½ × 4½	× 7½ inches	Web
⅝ × 1¾	× 7 inches	Support lugs

ORDER OF OPERATIONS

Dress no material to a width or length dimension.

1. Transfer from the layout (Fig. 115) to flange stock the proportions of the rabbets *C*. See Use of Bevel (page 74).

2. Dress the rabbets *C* to shape, and cut the ends of the rib stock to the required angle. This work may be done upon the band saw but is more accurately and quickly made upon the bench saw.

3. Draft the inside surface of the flange; then glue the stock for the ribs and the flange together. If the joint surfaces are firmly pressed together and rubbed, the material will need no further attention while the glue is drying.

4. Determine from the direction of the draft upon the inside of the flange the edge of the material that is to receive the web stock, and dress this surface square to the face of the flange. Since the outline of the ribs is to be laid out upon the opposite edge of the material, this edge surface is to be trued up.

5. Scribe the center line *A* about the flange, and lay off the height dimension of the pattern. Gage a line indicating the amount of finish allowed upon the surface of the flange as at *H* (Fig. 115). The centers of radii *B* are to locate upon the extension of this gage line.

Figure 117 illustrates an easy way of holding the job and providing the surfaces *K* and *L* upon which to locate the centers of the radii in laying out the shape of the ribs. Material *K* is also the means of holding the work in the vise. The

face plate *M* is used in this instance as a weight to hold material *L* in place.

6. Saw the inside shape of the ribs to their outline. Draft is provided by tilting the saw table. Dress out the fillets *E*, connecting the flange and ribs. Remove the saw marks from the inside surface of the ribs with coarse sandpaper.

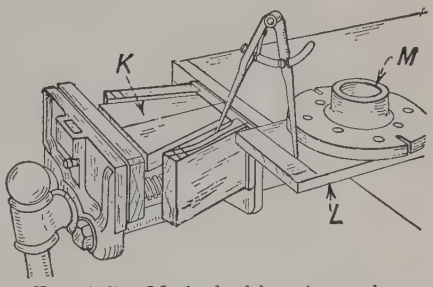


FIG. 117.—Method of locating and supporting the divider point when laying out the shape of the ribs.

7. Saw out the rabbets *D* (Fig. 115) that are to receive the ends of the lug stock. Figure 118 shows the rabbets as they will appear when sawed.

8. Plane the web material to required thickness, and glue it to the ribs and the flange. The rectangular shape of the web material should make projections of the web as at *A* (Fig. 118).

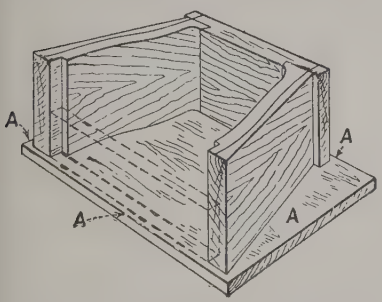


FIG. 118.—The pattern in course of construction. Shown in dotted outlines is the position of the material that is to form the support lugs.

9. Get out the material for lugs in one piece, plane it to thickness (thickness only), and provide draft upon the inside surface. In fitting this material into place, it will be found necessary to cut a corresponding taper upon the shoulder of the rabbets in order to have the face surface of the lugs lie perpendicular to the surface of the web.

The advantage of using one piece of stock is that it assures the correct alignment of the lugs and permits them to be shaped by the same sawing operation that reduces the pattern to form.

10. Dress the projecting edges *A* of the web flush with the face of the flange and lug material.

11. Saw the outside shape of the ribs; then sandpaper these surfaces. Figure 119 shows how the work will appear when the outside of the ribs has been sawed to shape. It also shows the outline of the openings and ribs laid out upon the various surfaces of the pattern and ready to be sawed.

12. Lay out the shape of the openings and the outline of the edge of the ribs.

Since the face of the ribs is curved, the outline of the edge of the ribs cannot be laid out directly upon this surface, but it is easily transferred to it from a paper templet. Cut the paper to the length of the surface *G*; then lay out the side view

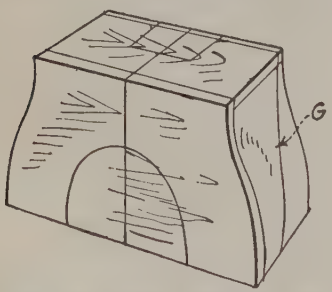


FIG. 119.—Work ready for the final sawing operation.

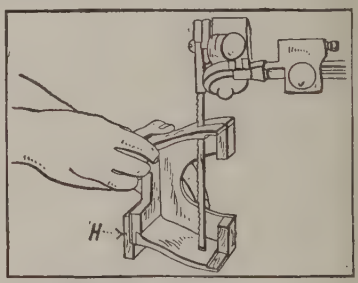


FIG. 120.—Sawing the pattern to the shape of its side view upon the band saw.

of the pattern upon it. The difference between the height of the pattern and the length of the templet is added to the $5\frac{3}{8}$-inch radius. This will make an approximation close enough for this outline.

13. Order of sawing operations: Saw the elliptical opening in the web. Saw the rectangular opening in the flange. Saw the work to its side view. This operation requires that the work be supported by a piece attached to the face of the flange, as shown at *H* (Fig. 120).

Caution: Never attempt to saw to shape an overhanging part of a piece of work that is not supported in direct line with the blade of the saw. The failure strictly to adhere to this practice may result in serious injury.

14. Round the corners, and reinforce the joints with brads.

PATTERN 13

BELL CRANK

Features presented:
The end lap
Application of templet
Sandpapering

Figure 121 is the drawing of a cast-steel bell crank.

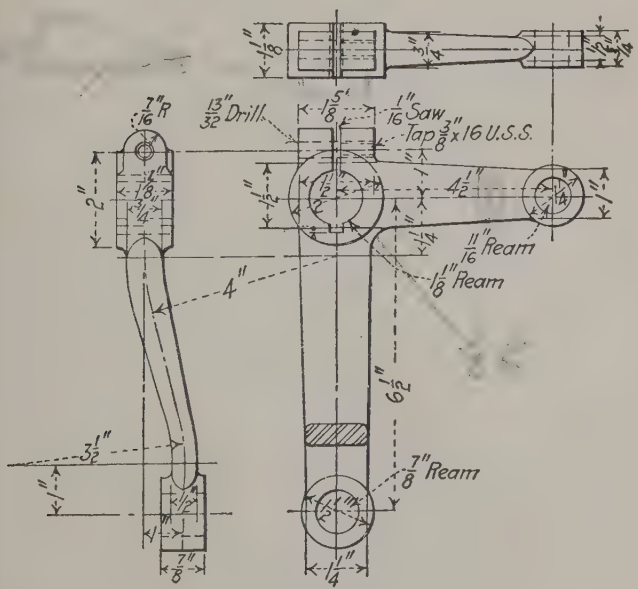


FIG. 121.

The material is joined together as shown in Fig. 122. This method of joining is known as the *end lap*. The end lap is made on a saw bench. The two arms of the pattern lie in

the direction of the grain of wood and therefore have the advantage of its maximum strength.

Make a layout of the pattern shown in Fig. 123. The layout needed is to aid in determining the dimensions of the required material and in the proportioning of the lap joint.

Stock required: $2\frac{1}{8} \times 2\frac{3}{8} \times 9\frac{1}{4}$ inches
$1\frac{1}{4} \times 2\frac{3}{8} \times 6\frac{3}{4}$ inches

ORDER OF OPERATIONS

1. Plane the two pieces of material to the width and thickness shown in Fig. 122, then make the joint.

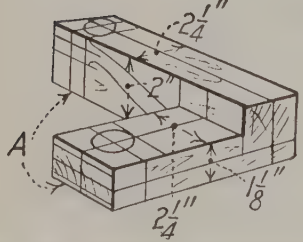


FIG. 122.—Method of gluing up the material for the bell-crank pattern.

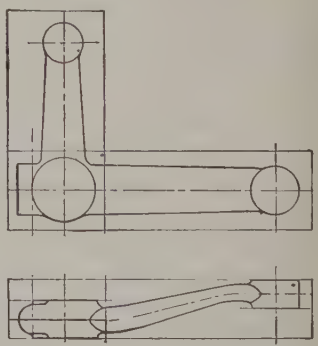


FIG. 123.—The layout of the bell-crank pattern.

2. Glue parts together. The thickness of the pieces as given is a required pattern dimension; therefore the joint should be tested before gluing in order to see that the surfaces *A* of the pieces lie in the same plane.

3. Square up the outer edges of the pieces, and lay out the work from these surfaces.

4. Figure 124*A* shows the work at the completion of operation 4.

The material has been reduced as at *B* to the thickness of the bosses. The centers of the bosses have been located and their circumferences scribed, as shown.

5. Upon the inside edge *C* of the material, lay out the thickness of the arms. The thickness of the offset arm may be

traced from a paper or wood templet or laid out directly upon the material.

6. Saw the work to this outline.

7. Figure 124*B* shows the work at the completion of operation 7.

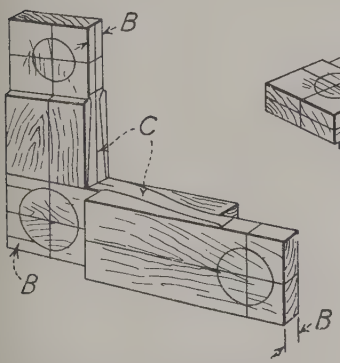


FIG. 124*A*.—The thickness of the arms laid out upon the material and ready to be sawed to shape.

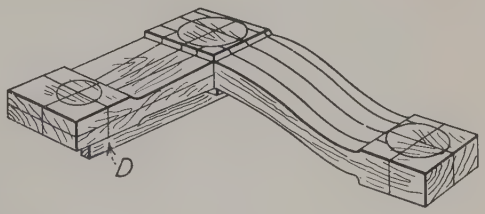


FIG. 124*B*.—The laying out of the arms and bosses completed and the work ready to be sawed to this outline.

The material has been sawed and dressed to the thickness of the arms and the shape of the arms laid out.

8. Saw the work to this outline. Attach a piece as at *D* to support the work while this operation is being performed.

9. Dress the bosses to shape, and round the edge of the arms as shown by the cross section of one of the arms (Fig. 121). Use the spoke shave for this work. Figure 125 illustrates how a strip of sandpaper is used in finishing the rounded edge of the arms.

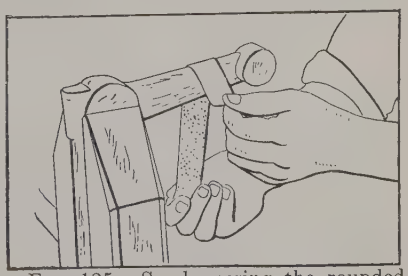


FIG. 125.—Sandpapering the rounded edges of the bell-crank pattern with a strip of sandpaper.

A cross-section or sectional view of a casting is the interior or outlined surface that would be presented if the casting were cut in two (see section xx, Fig. 146, page 139).

PATTERN 14

TOOL-REST SLIDE

Features presented:

Giving greater strength to a pattern by the arrangement of the core print

Arranging a core print so as to simplify the construction of the core box

Proportioning a core print so as to balance a core

Spot-gluing

Figure 126 shows the drawing of a cast-iron tool-rest slide.

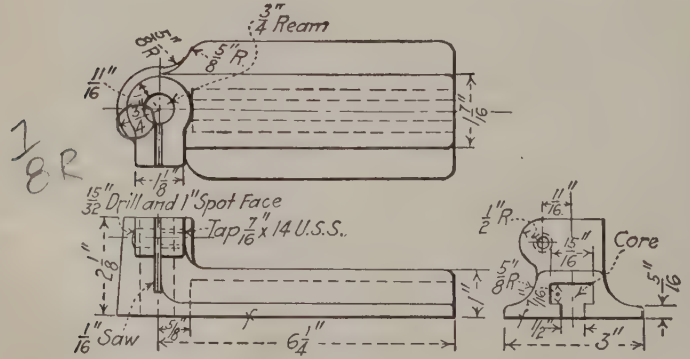


Fig. 126.

The casting is made up of a flanged body, a conical-shaped boss, and a clamping lug. Extending through the body of the casting to within 5/8 inch of the center of the boss is a cored T-head bolt slot.

The shape of the casting affords only one practical way in which to mold the pattern, and that is to part it longitudinally, as shown in Fig. 127.

An end-view layout of the pattern as shown in Fig. 128 does not convey any idea as to the thickness of the core forming the opening in the casting.

Note how the thickness of the core print is made to the width dimension *A* of the T-head bolt slot. Making the core print to this dimension has three advantages. First, it gives added strength to the pattern. Second, the core is made of uniform thickness and will lie flat upon the core plate when drying. Third, this arrangement of the core print simplifies the construction of the core box.

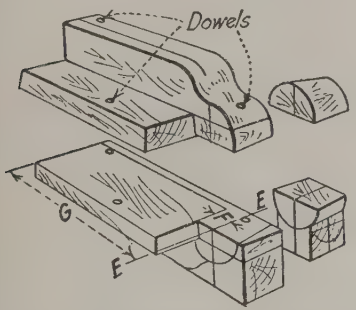


FIG. 127.—The drag and cope part of the pattern at different stages of completion.

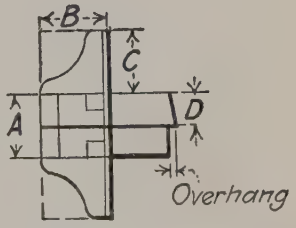


FIG. 128.—The layout of the end view of the pattern.

When a core lying horizontally in a mold receives its entire support from along one side, as in this case, the core-print portion is to outweigh or overbalance that portion of the core which is surrounded by the molten metal. Since the T-head bolt-slot core extends into the mold $\frac{7}{8}$ inch, the print is to extend $1\frac{1}{8}$ inch from the face of the pattern.

The body of the pattern is made up of four pieces of material, and the cross section of these pieces is obtained from the layout. The layout is used for direct reference in proportioning the core box.

Stock required: $\frac{5}{8} \times 2\frac{1}{2} \times 15$ inches, $1\frac{1}{8} \times 1\frac{1}{4} \times 15$ inches } Body of pattern

$1\frac{1}{4} \times 1\frac{1}{2} \times 4\frac{1}{4}$ inches Boss

ORDER OF OPERATIONS

1. Dress the material for the body of the pattern to the required dimensions *B*, *C*, and *D* (Fig. 128), then glue the pieces together, as shown in Fig. 129.

2. Separate the material at the middle of its length. Set the dowel pins at about the locations shown (Fig. 127).

3. Scribe center line *E*, and lay off the dimension *F*, which is the distance from the center line of the boss to the end of the core print.

4. Dress this end of the core print to shape. (Refer to the information on overhang given the cope half of core prints, page 99.)

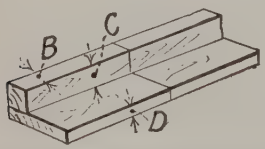


FIG. 129.—The glued-up stock for the body of the pattern.

FIG. 130.—The boss and its attached clamping lug partly shaped and ready to be secured to the body of the pattern.

5. Lay out the shape of the boss end of the pattern.

Figure 127 shows the drag part of the pattern laid out.

6. Dress the work to dimension *G*.

7. Saw the boss end of the pattern to shape. Do not dress to the exact outline. The cope half of the pattern shows the work at this stage of completion.

8. Lay out and dress to shape the part of the boss shown in Fig. 130. Small parted members such as these are more easily made if the material is spot-glued together and the member shaped as one piece, then the two halves separated with a thin knife blade.

9. Attach the parts, and dress this end of the pattern to shape.

10. Dress the body of the pattern to the required cross section.

CORE BOX FOR THE TOOL-REST SLIDE PATTERN

Features presented:

Core-box construction

Stock required:		
	1 × 2½ × 13 inches	Frame
	⅞ × 4½ × 10 inches	Bottom board
	⅝ × ⅞ × 8 inches	Strip *B*
	⅜ × ⅝ × 6 inches	Strip *A*

Figure 131 illustrates the core that forms the T-head slot in the tool-rest slide casting and the frame in which the core is shaped.

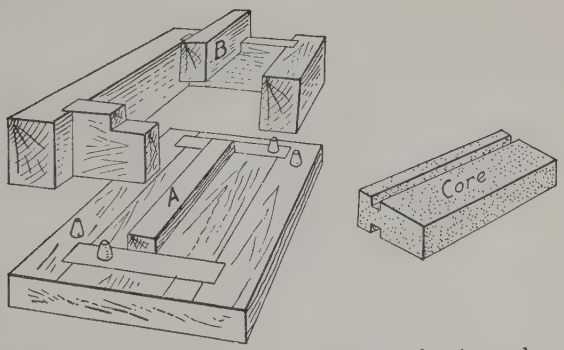


FIG. 131.—The core box used in forming the core that is employed in connection with the tool-rest slide pattern.

To show better the arrangement of the box, a section of one end, one side, and a part of strip *B* have been cut away. The frame is shown above the bottom board to which it is attached with dowels.

The depressions in the core are formed by the strips *A* and *B*. Strip *A* is attached to the bottom board. Strip *B* is a rectangular loose strip. It is located and held in place by a notch cut in the end pieces of the frame. To give stiffness to strip *B*, it is proportioned so as to project about ½ inch above the frame, as shown.

The relative position of the frame of the core box to the bottom board is to be indicated by the outline of the inside of the frame being traced upon the surface of the board.

The location of strip *B* upon the frame is to be indicated with a tally mark. A tally mark is easily made by duplicating a number, as 1-1, 2-2, or 3-3, etc.

All parts and pieces of the core box are to be stamped or marked with the number of the pattern.

In making the core, strip *B* is held in position while the box is rammed up. The strip is then removed and this face of the core laid upon the core plate. The bottom board is then lifted off and the frame removed.

For construction of frame, refer to instruction given with the core frame for pattern 9 (page 101).

QUESTIONS

1. What is understood by countersawing?
2. For what purpose is the spoke shave used?
3. What is understood by the term *lateral surface?*
4. What machine may be used to remove the surplus waste material from the cavity of semicircular core boxes?
5. What tools may be used to dress to shape the surface of semicircular core boxes?
6. On what principle is the V-type core-box plane constructed?
7. For what purposes is the rabbet plane used?
8. How does the bit of a rabbet plane differ from the bit of a jack plane?
9. How is the size of a rabbet plane specified?
10. Why may the accuracy of the surface of a semicircular core cavity be tested with a square?
11. What is understood by the layout of a pattern?
12. Why is a layout of some patterns necessary?
13. Why is a layout necessary for the lathe-leg pattern?
14. What are the principal features presented by the lathe-leg pattern?
15. What should be avoided in whetting the blade of a spoke shave?
16. Where is the end lap used?
17. What is understood by the cross section of a casting?
18. How should the sandpaper be used to finish rounded edges?
19. What is spot-gluing?
20. What is meant by "to balance a core"?
21. What is meant by a T-head bolt slot?
22. For what purpose are tally marks used?

PATTERN 15

STEADY REST

Features presented:

Simplifying the parting of a mold by the use of a core

Registering a core Tell-tales.

The compass saw

The spindle sander

Locating material upon a face plate

Strengthening a fragile section of a pattern

Figure 132 is the drawing of a cast-iron steady rest.

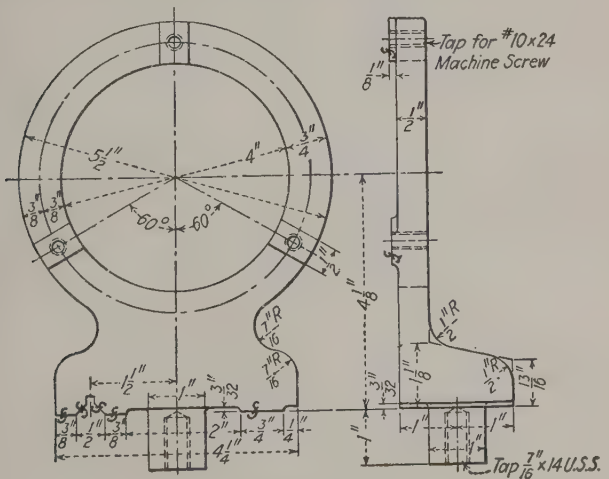


Fig. 132.

The casting is made up of a web, a flange, a boss, and three pads.

Dry-sand cores are used not only to produce holes, cavities, and the interior shape of castings but also very frequently to form a plane or straight parting of a mold.

This feature is presented by the pattern for the steady rest. Notice how a 1-inch diameter boss extends out from the depressed surface of the face of the flange; then imagine how the parting of the mold would have to be formed if the face of the pattern were made like that of the casting.

This objectionable parting is eliminated if a core print is used, as shown in Fig. 133*A*, and the face of the flange formed by a dry-sand core. To assure a correct setting of the core in the mold, the print is made to extend, as at *A*, about ¼ inch beyond the flange, as shown.

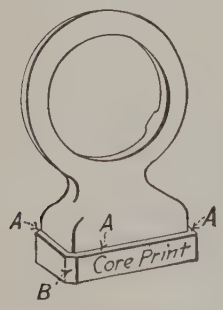


FIG. 133*A*.—The pattern for the steady rest.

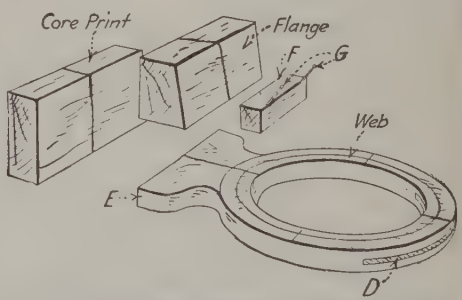


FIG. 133*B*.—The pattern members partly shaped and ready to be attached together.

To avoid placing the core in the mold in any other position than that intended, one corner of the print at *B* is chamfered as shown and the corresponding corner of the core *C* (Fig. 137) shaped similarly. This is *registering a core*. The raised surface *H* of the core does not extend the full width of the core. By making the raised surface the width of the flange, no core-print projection of this shape beyond the flange is necessary.

No attention is given the V-shaped slot in the face of the flange; forming it requires a machine-shop operation. If the common allowance for machine finish is made upon the surface of a groove and this allowance leaves a very small groove to be made in the pattern, no consideration is given the groove.

Figure 133*B* illustrates the separated parts of the pattern. The flange and the core print are shown opposite the surface of the web to which they are later attached.

The 4-inch hole through the web may be formed by one of three methods: by sawing it out with a compass saw, as shown in Fig. 134, then dressing it to shape; or by securing the web material to a face plate, as shown in Fig. 135, and turning out the hole. If this method is employed, place no

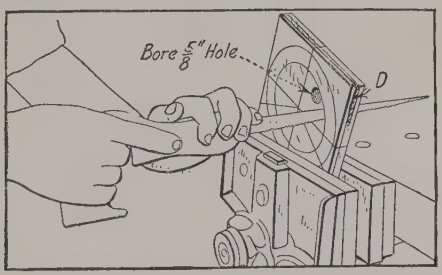


Fig. 134.—Sawing out the hole in the web material with a compass saw.

center lines upon the material until it has been secured to the face plate and the center of rotation found. The center lines are then to be drawn through this point and the shape of the object laid out and the hole turned. In most cases, this method of procedure will save time and promote accuracy,

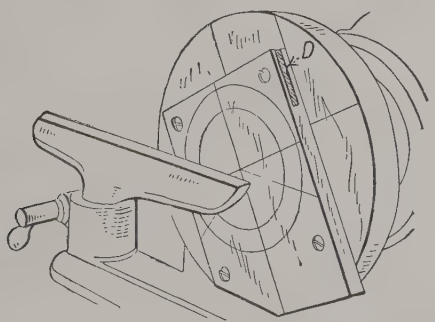


Fig. 135.—The web material mounted upon a face plate for the turning out of the hole.

since it is not always an easy matter to locate a definite point upon a piece of material directly over the center of rotation of a face plate.

The third method consists of making a joint in the material along the middle of its width and sawing out the hole, then

gluing it together, and completing the circular surface upon a spindle sander as shown in Fig. 136.

Spindle Sander.—The spindle sander shown in Fig. 136 is used in sanding to shape concave surfaces and surfaces that are not adaptable to the disk sander. The spindle or cylinder to which the sandpaper is affixed has a revolving and oscillating movement. An adjustable feature of the table permits it to be locked at an angle to the axis of the spindle.

Sanding rolls or tubes that slip over the different diameter cylinders may be obtained through any pattern-supply company.

Stock required:		
$\frac{5}{8} \times 6 \times 7\frac{1}{2}$ inches	Web
$1\frac{3}{8} \times 1\frac{3}{4} \times 4\frac{3}{4}$ inches	Flange
$1 \times 2\frac{1}{2} \times 5\frac{1}{4}$ inches	Core print
$\frac{5}{8} \times \frac{5}{8} \times 3\frac{1}{2}$ inches	Fillet stock
$\frac{3}{8} \times \frac{3}{4} \times 4$ inches	Pads
$\frac{1}{4} \times 1\frac{1}{2} \times 6\frac{1}{2}$ inches	Tongue

ORDER OF OPERATIONS

1. Prepare the web material. *Note:* If a tongue is inserted in the web material, as at *D* (Fig. 134), it will greatly strengthen the short grain wood that occurs at this point in the web. It consists of a saw cut into which a tongue or spline is inserted and glued.

If the enclosed waste material is to be turned out, mount the material upon a face plate, as shown in Fig. 135. Locate the center of rotation; then scribe the center lines through this point.

2. Lay out the shape of the web; then dress or turn the circular opening.

3. Saw and dress the outer edge of the web to shape. When the surfaces of two members of a pattern are to coincide, as the ends of the flange and edge of web, as at *E* (Fig. 133*B*), it is a good practice to make the width of the web at this point a trifle full. This permits the edge of the web to be dressed off to conform to the length of the flange after the parts are attached.

4. Dress the flange material to length and cross section, and attach it to the web. Fit and glue into the corner formed by the flange and the web the piece of stock *F*; it is to form the ½-inch fillet. Brads are driven in, as at *G*, holding the piece in place while the glue is setting. The application of the wood fillet is made to this pattern in order that this construction may be applied if desired. Ordinarily, a leather fillet would be used.

5. Dress the ends of the flange material to conform to the shape of the web.

6. Dress the core print to shape, and attach. The thickness of the core print is equal to the distance the boss extends out beyond the finished face of the flange.

7. Attach the three pads. The end surfaces of the pads are to leave their impression in the drag. (Draft accordingly.)

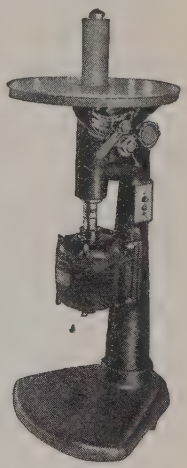


FIG. 136.—The spindle sander.

When the thickness of a core represents the length of a projection on a casting, as in the case of the boss, the outline of the projection should be indicated on the face of the core print in the body color of the pattern.

CORE BOX FOR THE STEADY-REST PATTERN

Features presented:

Core-box construction

Stock required:		
1 × 2½ × 12 inches	Frame
⅞ × 4½ × 9 inches	Bottom board
1¼ × 1¼ × 2½ inches	Boss

Figure 137*A* illustrates the core box for the steady-rest pattern and Fig. 137*B* the core formed within the box. To show better the arrangement of the box and the bottom board, one end of the frame and a section of one side have been cut away. The raised surface of the core *H* is formed by the depression *I* in the bottom board.

If the drawing of the steady rest has been carefully studied, it will have been observed that this depression does not occur at the middle of the length of the core. The hole through the core is formed by the boss *K*. The boss is attached to the bottom board by a dowel ½ inch in diameter.

To check or verify by observation the arrangement of a core box with the pattern, hold the box in its relative position to

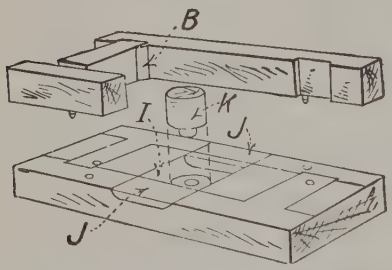
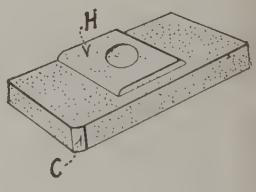


FIG. 137*A*.—The core box used in connection with the steady-rest pattern.



Core.

FIG. 137*B*.—The core formed within the core box.

the pattern; then compare its outlines and the arrangement of the parts.

Cut out depression *I* the full width of the bottom board; sandpaper it; then glue in the filling pieces *J*. In attaching the boss to the bottom board, keep in mind that its center is not located at the middle of the width of the core. The triangular block *B* chamfers the corner of the core at *C* and marks the core for its correct setting in the mold.

PATTERN 16

SHACKLE

Features presented:

Construction

Figure 138 is the drawing of a cast-steel shackle. The casting is composed of a double and a single boss united by two ribs; the ribs are connected by a web.

Unless instructions are otherwise, finished holes in steel castings of $1\frac{1}{2}$-inch diameter or less, will be drilled.

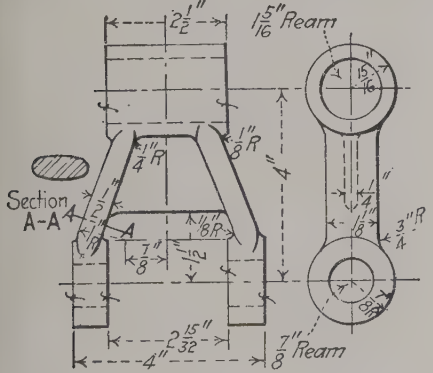


Fig. 138.

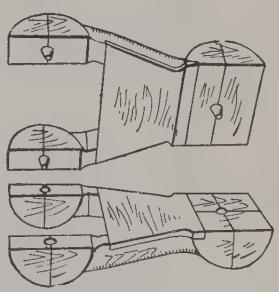


Fig. 139.—The pattern for the shackle. Note how the grain of the wood of the web is laid transversely to that of the ribs.

Figure 139 illustrates the pattern. Note how the grain of wood of the web is laid in a transverse direction to that of the ribs. This construction gives greater strength to the pattern.

Stock required: $1\frac{1}{8} \times 4\frac{1}{2} \times 13$ inches Body

$\frac{3}{16} \times 2\frac{1}{8} \times 9$ inches Web

ORDER OF OPERATIONS

1. Arrange the parting, and set the dowels.

2. Dress the material to the greatest width of the pattern; then scribe the longitudinal and transverse center lines.

3. Upon each edge lay out the side view of the pattern; then dress the material tangent to the circumference of the bosses as shown in Fig. 140.

4. Upon each face of the material, lay out the top view of the pattern.

5. Upon each edge, lay out the depression that is to receive the web. Make distance *C* about $\frac{3}{4}$ inch and distance *D* about 2 inches.

6. Dress out the depression for the web.

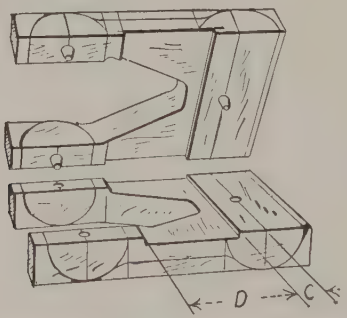


FIG. 140.—The pattern for the shackle in process of making.

7. Saw and dress to shape the inside surfaces of the ribs and double boss. Figure 140 illustrates the work at this stage of completion.

8. Attach the web.

9. Saw and dress the work to the outline of the bosses and ribs.

10. Rescribe those lines on the face of the material that were destroyed by the previous operation; then saw and dress the work to this shape of the pattern.

11. Dress to shape the lateral surface of the boss that lies between the ribs.

PATTERN 17

BRACKET

Features presented:

Construction

Using a core print to protect a pattern from being distorted by the ramming of the sand

Figure 141 is the drawing of a cast-iron bracket.

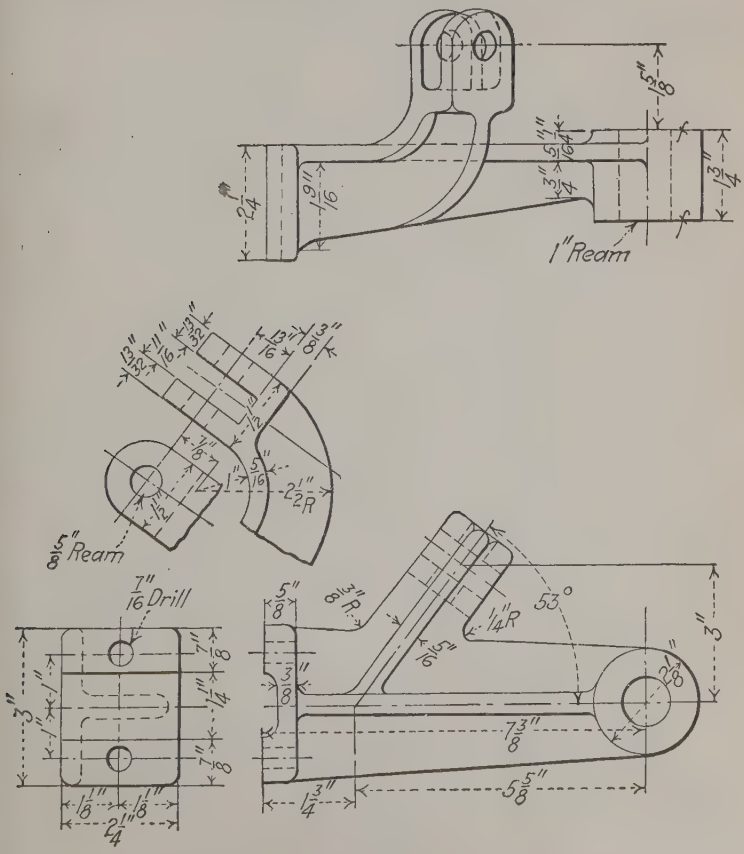


Fig. 141.

The pattern for the bracket is illustrated in Fig. 142. The ears *C* will be molded in the cope; this arrangement necessitates that a parting in the pattern be made at *D*.

What often appears as a difficult pattern will, after a little effort on the part of the imagination, resolve itself into a num-

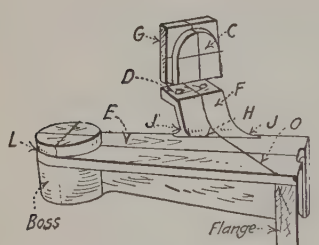


Fig. 142. -The pattern for the bracket.

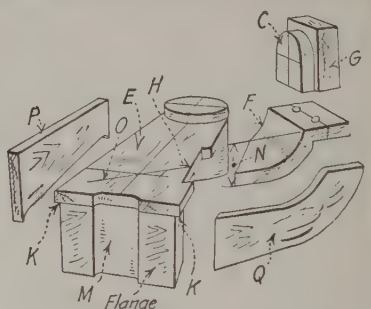


Fig. 143.—The detached members of the bracket pattern in their relative positions for assembling.

ber of simply shaped parts as shown in Fig. 143. This is true of the bracket pattern, for if each member is considered separately as it is shown, the construction of the pattern becomes a simple problem.

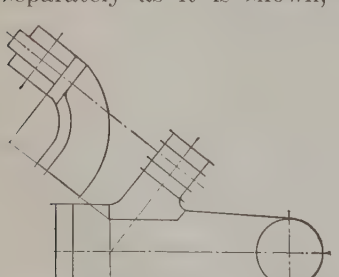


Fig. 144.—The layout of the pattern for the bracket.

The web is made up of two pieces of material; the main portion of the web *E* supports the boss and the flange; the curved portion of the web *F* supports the ears *C*. The ears *C* have a small bearing surface upon the web, and the ramming of the mold will probably distort them. To prevent this distortion, a core print *G* secures the ears together and keeps them in place.

A partial layout of the pattern, as shown in Fig. 144, is required. From it are obtained the dimensions of the material for web *F*. Attention is called to the fact that the web *F*,

which supports the ears, is set about ¼ inch into the web *E*, at *H*. This is done to strengthen the joint and to allow stock for the fillets *J*.

Stock required:	7/16 × 3½ × 9 inches	Web *E*
	1½ × 2⅜ × 4 inches	Web *F*
	¾ × 2¼ × 3½ inches	Flange
	1½ × 2½ × 2½ inches	Boss
	½ × 2½ × 2½ inches	Boss
	½ × 1¾ × 3¾ inches	Ears
	13/16 × 2¼ × 2¼ inches	Core print
	7/16 × 1¾ × 6½ inches	Rib *P*
	7/16 × 2½ × 5½ inches	Rib *Q*

ORDER OF OPERATIONS

1. Prepare the material for the web *E*; then lay out the shape of this member. Do not dress to shape.

When the surfaces of two members of a pattern are to coincide, as the ends of the flange and the edges of the web, as at *K*, or the end of the web with the cylindrical surface of the boss, as at *L*, the outline of the edge of the web should be made a trifle full; the web is then dressed off after the parts have been attached. Likewise, when a depression occurs in the surface of two members, as at *M*, the depression should be dressed out after the parts have been put together.

2. Dress to shape the opening *H*, which is to receive web *F*; then saw the web *E* to shape.

3. Web *F* is made by dressing a block to the required width and to the thickness *N*. Fit the block into the opening *H*; then scribe the center line *O*, and locate the position of the core print. Lay out the outline of web *F* upon the edge surface of the material. Do not dress web to shape.

4. Dress the core print *G* to shape, and dowel it in place.

5. Dress the ears *C* to shape, and attach to the core print.

6. Saw and dress the web *F* to the shape laid out upon the edge surfaces of the material. Lay out the outline of web *F* upon the parting surface, and saw and dress to this shape.

7. Glue webs *E* and *F* together; then dress out the fillets *J*.

8. Shape the two parts of the boss and the flange, and attach parts to web *E*.

9. Fit the material for rib *P* into place; then dress to shape, and attach. Fit the material for rib *Q* into place; then dress to shape, and attach.

CORE FRAME FOR THE BRACKET PATTERN

Features presented:

Band-sawing a core frame to shape

When cores are of approximately the dimensions required by this job, this type of core frame may be used.

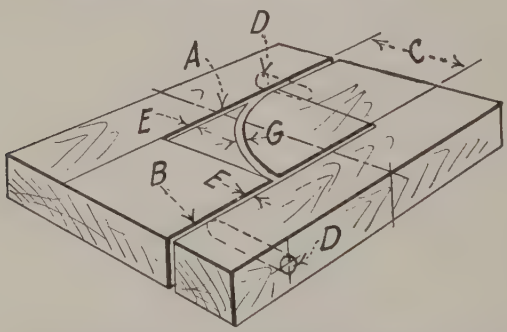


FIG. 145.—The core frame used to supplement connection of the pattern for the bracket.

Figure 145 shows the core frame in course of making. The material should be about 2 inches greater in width and 3½ inches greater in length than the width-and-length dimensions of the core. The material is planed to the required thickness of the core; then the shape of the core is laid out upon one face.

The lines *A* and *B*, which represent the width of the core cavity *C*, are gaged throughout the length of the material, as shown. Dowel-pin holes are bored as at *D*.

Make saw cuts as represented by *E* along the inside of the line *A* and along the outside of the line *B*. The frame is separated by making a saw cut as indicated by *G*. Saw the core cavity to the length dimension, then sandpaper, and insert the dowel pins.

PATTERN 18

TAIL STOCK

Features presented:

Construction
Loose-piece feature
Scribing lines upon irregular surfaces
Application of templets
Application of countersawing
Indicating the location of loose parts of patterns
Indicating where fillets are required in the casting

Figure 146 is the drawing of a cast-iron tail stock.

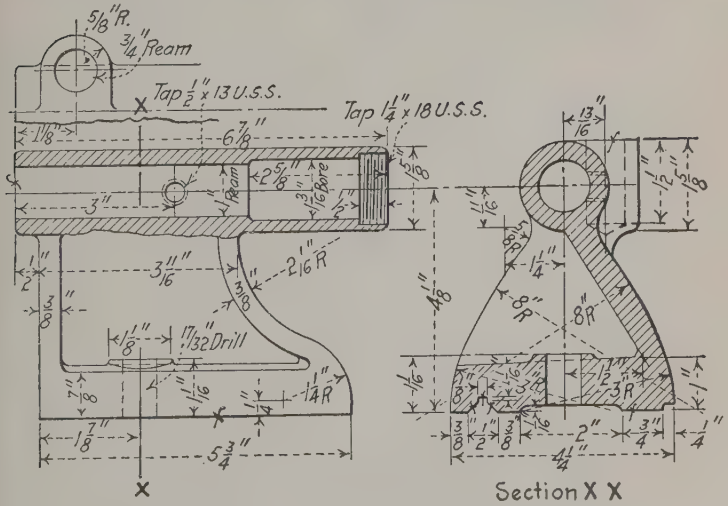


Fig. 146.

A longitudinal section of the barrel is given to show more clearly the interior of this member. The other view of the casting is that of a cross section along the line *XX*.

The pattern is molded upon its side; the clamping lug is parted from the barrel so that it may lift off with the cope.

If a slight clearance depression of $\frac{1}{16}$ inch or less is required throughout the length of a finished surface, as in the face of the flange, and it would require the use of a dry-sand core or a part of the pattern to be made loose in order to mold the pattern, the surface of the casting is made plane and the depression machined out.

The layout of the pattern required is shown by Fig. 147. It gives the names of the various members of the casting.

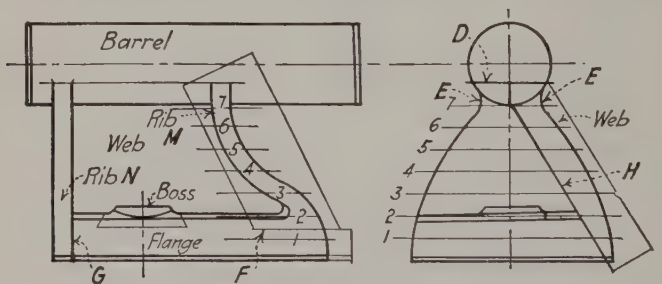


Fig. 147.—The layout of the pattern for the tail stock.

When a projection occurs (as the boss) on a casting at a point beyond the limit of the parting of the mold, the loose-piece feature in pattern construction is applied.

To permit the boss upon the top surface of the flange to remain in the sand until the withdrawal of the body of the pattern, it is made a loose piece. It is located and held in place by the tongue *B* (Fig. 148). The tongue is held in place by its beveled edges engaging a corresponding bevel upon the sides of slot, as at *C*. This is commonly called a *dovetail tongue*. By giving a slant of about $\frac{3}{4}$ to 12 inches to each edge of the tongue, it will instantly release itself from the body of the pattern. The tongue affords the means whereby the loose piece may be drawn and lifted out of the mold.

Whenever a loose piece is to be drawn and taken out through a narrow cavity of a mold, as in the present case, the dovetail feature should be applied. When considering the loose-piece

feature, be sure that the space into which the loose piece is to be drawn will easily permit of this operation.

Carefully study, in conjunction with the layout, the construction of the pattern as illustrated by Fig. 148. Note the arrangement of the joints between the adjacent pieces of material. Note how the joint between the barrel and the body of the pattern is made along the line *D* (Fig. 147). Line *D* is located by the point of tangency between the radii of the fillets *E* and the circumference of the barrel.

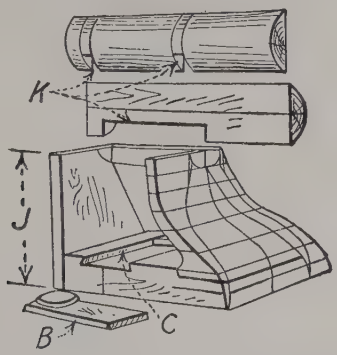


FIG. 148.—The pattern for the tail stock in process of construction.

In getting out the material, keep in mind that the pattern is sawed to the shape of the end view and that ample waste ($\frac{1}{2}$ inch) is to be allowed for this operation.

Stock required:

$1\frac{1}{4}$	× $4\frac{3}{4}$	× 6	inches, flange
$\frac{7}{8}$	× 5	× $6\frac{1}{4}$	inches, web
$1\frac{3}{8}$	× $4\frac{3}{4}$	× $4\frac{3}{4}$	inches, rib *M*
$\frac{1}{2}$	× $4\frac{3}{4}$	× $4\frac{3}{4}$	inches, rib *N*
1	× 2	× $17\frac{1}{2}$	inches, barrel
$\frac{5}{16}$	× $1\frac{3}{4}$	× 6	inches, tongue and boss
$1\frac{3}{4}$	× $2\frac{1}{4}$	× $2\frac{1}{2}$	inches, clamping lug
$\frac{3}{8}$	× $2\frac{1}{4}$	× $2\frac{1}{2}$	inches, clamping lug

ORDER OF OPERATIONS

1. Make the rabbet *F* (Fig. 147) in flange material that is to receive the stock for the rib *M*; then plane flange to its diminishing thickness.

2. Dress out the slot *C* in flange ($\frac{3}{16}$ inch deep), which is to receive the tongue *B*. Fit the tongue snugly into the slot. Dress the end of the flange at *G*, to which is to be attached the stock for the rib *N*.

3. Glue parts together. Use brads temporarily to hold the parts together while the glue is setting. Place a protecting strip of about $\frac{1}{2}$-inch thickness between the brad heads and the work. The strip will permit the withdrawal of the brads.

4. Dress the edge surfaces of the work square to the face of the flange and to its greatest parallel width (about $4\frac{5}{8}$ inches). Upon the edge of the work that is to be the drag side of the pattern, lay out the shape of the rib *M*. Provide for ample draft upon the inside surface. Then saw the rib to the required thickness.

5. Dress out the fillet connecting the surface of the rib with that of the flange; then sandpaper the inside surfaces of the rib.

6. On the waste material cut from the outside of the rib *M*; locate and scribe a line that will correspond in location to line *H* of the layout. Dress the material to this line; then replace the material upon the rib, and transfer line *H* to the rib. Line *H* may also be scribed between the given points by the method illustrated with pattern 29 (page 219) or by an angle plate, as illustrated in Fig. 235.

7. Separate the work along the line *H*; then fit into place and attach the web material. Use brads as previously explained to hold parts together while the glue is setting.

8. Guiding the saw by the curved surface of the rib *M*, saw off the protruding end of the web material. Dress and sandpaper this surface; then saw the body of the pattern to its required height *J* (Fig. 148).

9. The curved surface of the rib *M* will not easily permit the end-view shape of the pattern to be made directly upon it; therefore, a paper templet, as shown in Fig. 149, of the end-view shape is made and the outline of the pattern traced from it. The shape of the end view of the pattern being the same on each side of the center line, a templet of one-half the end view is sufficient.

The shape of the templet is developed by dividing the height of the body of the pattern, as seen in Fig. 147, into a number of equal parts, as 1, 2, 3, etc., then squaring these lines across the surface of the rib *M*. The spacings of these lines are transferred to a piece of heavy paper while it is held and caused to conform to the curved surface of the rib.

The edge of paper that represents the center line of the templet must coincide with the center line of the pattern. Transfer to the paper from the corresponding lines of the layout the half width of the pattern at these stations 1, 2, 3, etc., and connect the points obtained by a line drawn free hand or with the aid of a French curve. Cut the paper to this out-

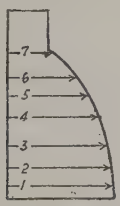


FIG. 149.—Paper templet required for tracing the end view of the pattern.

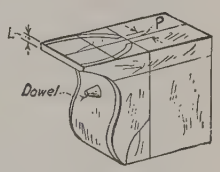


FIG. 150.—The clamping lug in course of shaping.

line; then trace its shape upon the curved surface of the rib, as shown in Fig. 148.

10. Turn the barrel portion of the pattern. The barrel is shown in Fig. 148 above the surface of the body to which it is later attached. To facilitate the laying out and sawing to shape of the joint *K*, the barrel is made in halves.

11. Saw the body of the pattern to its end-view shape; attach the barrel; then dress out the fillets *E*.

The material from which the clamping lug is sawed is shown in Fig. 150. It is fitted into place, doweled, then dressed to required height, as shown.

To avoid the thin short grain wood that would occur at *L* if the lug were made from one piece of material, it is made up of two pieces, the grain of the pieces lying in a transverse direction. The piece that forms the thin edge is about $\frac{3}{8}$ inch thick.

Ample stock (about 1½ inches) is allowed beyond the limit of the lug that the work may be firmly held while the lug is being sawed to shape.

Lay out the top and side views of the lug upon the material, then saw to the top view of the lug. In performing this operation, do not complete the entire outline of the lug, but allow ¼ inch of stock to remain, as at *P*, to hold the material together. The sawing to shape of the side view separates the lug from the waste.

12. Saw the clamping lug to its top view, then to its side views.

The fillet connecting the lower part of the lug with the surface of the web is to be dressed to conform to the convexed surface of the lug. The surface of the ribs *M* and *N* (Fig. 147) that is above the joint line *H* is to be coped; it is to be drafted accordingly. Whenever a part of a pattern, as in the case of the lug, is made loose from the body, its position should be plainly indicated. The general practice is to place the parts in position; then, with a small marking brush, apply a line of shellac, of a contrasting color, along the corner formed by the intersecting surfaces. The marking calls attention to the fact not only that a part of the pattern is required at this location but also that the molder is to finish the mold in such a way as to form a fillet in the corner of the casting.

PATTERN 19

YOKE

Features presented:

Construction

Strengthening a yoke-shaped pattern with a tie piece

Casting in a tie piece to prevent the distortion of the casting

Stopping off a part of a pattern impression that is not wanted as a part of the required casting

Figure 151 is the drawing of a cast-iron yoke.

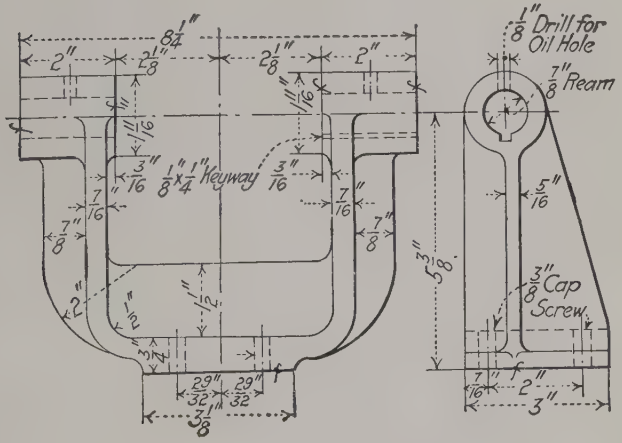


Fig. 151.

Because the axis of the hubs concurs with the cope face of the web, the pattern is parted along this surface as shown in Fig. 152*A*. The two hubs *A* are interconnected by a ¾-inch diameter tie piece *B*.

Since the tie piece *B* is a pattern feature; no reference is made to it on the drawing. A tie piece greatly adds to the

strength of a pattern of this shape. It is easily stopped off if it is not desired to have it function in the casting.

Stopping off is the term applied to the operation of filling in with sand a depression left by a pattern. When a tie piece is not intended to be cast in, it is so indicated. (See page 175).

In the production of a yoke-shaped casting, it is good practice to cast the tie piece in; otherwise little or no contraction will have taken place between the hubs. This would cause a distorted casting. The tie piece is later removed from the casting during the machining process.

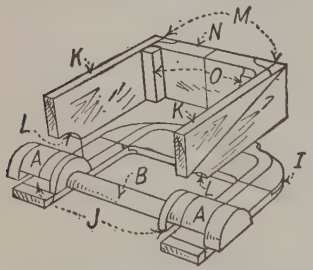


FIG. 152*A*.—The members of the drag of the pattern in course of assembling.

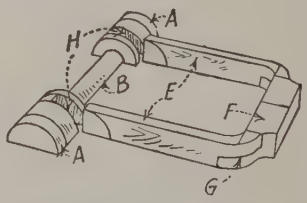


FIG. 152*B*.—The two cope members shaped and in position for gluing together.

The separated parts of the drag half of the pattern are illustrated in Fig. 152*A*, and the cope half of the pattern in Fig. 152*B*. The hubs are cut out as at *H* to receive the ribs *E*. The hubs *A* of the drag part of the pattern are cut out as at *J* to receive the web.

The ribs *K* of the drag are rigidly attached to the web. No advantage would be derived by letting the ribs into the hubs; therefore they are dressed to fit, as at *L*, the convex surface of the hubs. A butt joint, as at *M*, is used to join the flange *N* and the ribs *K*. The fillet material at *O* is glued in place, then dressed to shape.

A partial layout of the pattern, as shown in Fig. 153, will aid in the work.

The information given with pattern 15, page 131, regarding the use of fillets advised the application of leather fillets unless

the requirements of the pattern made the application of struck fillets desirable. This pattern illustrates one of the uses of a struck fillet. In this case, the struck fillet reinforces the pattern at this point.

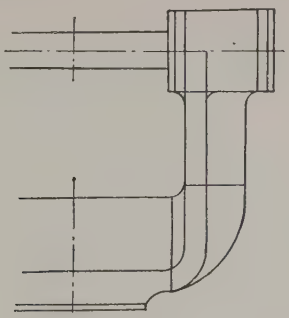


FIG. 153.—The layout of the pattern for the yoke.

To assemble flange *N* and ribs *K*, attach the flange to the web temporarily, with brads. Fit the ribs over the hubs, as at *L*, and glue the ribs to the flange. Glue in the blocks *O*. When the glue has set, the frame thus formed is removed, dressed to shape, and returned to its place and attached.

The Cornering Tool.—The cornering tool, as illustrated in Fig. 154, is used for rounding the corners of patterns. It is

FIG. 154.—The cornering-tool.

a flat steel bar that is so formed and ground at each end as to produce an elliptical cutting edge. The elliptical shape of the cutting edge permits a cut of a limited depth to be taken in either direction.

PATTERN 20

SEPARATOR

Features presented:

Locating a core above or below the parting of the mold

Drop core prints

Making drop core prints

Core-box construction

Figure 155 is the drawing of a cast-iron separator. The casting is made up of a web, two flanges, and a rib. The drawing specifies that the holes in the flanges are to be cored.

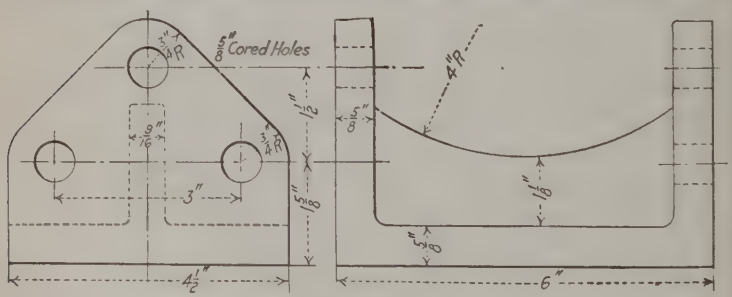


Fig. 155.

Figure 156 illustrates the pattern. Rabbet joints secure the flanges to the web. The rib is fitted in between the two flanges. The core prints (drop prints) visible in the illustration are indicated by *A* and *B*. The shape of the core prints does not convey any idea as to the shape of that portion of the cores that forms the holes in the casting. The cross section of the mold, Fig. 157, illustrates this feature.

The shape of the portion of the core that forms the hole through the flange is below the parting of the mold, at *C*; the core-print portion of the core is indicated by *D*. The core

print not only forms a seat for the core, but it leaves an opening through which the core is dropped to its proper location.

The shape of the portion *D* of the core is made to correspond to this part of the core print. It is the means by which the

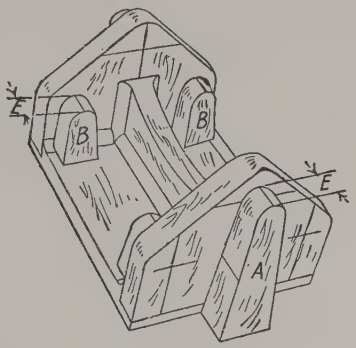


FIG. 156.—The pattern for the separator casting.

core is set and held in place and the core-print depression closed or stopped off.

Make the dimensions *E* (Fig. 156) of the core prints equal to the thickness of the flange. This proportion makes a good

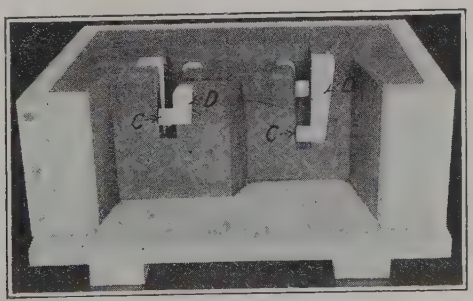


FIG. 157.—Sectional view of the drag part of the mold for the separator casting showing the drop cores in place.

bearing for the core. Make the slant of the sides and the face of the core prints 1 inch in 12 inches.

Figure 158 illustrates a way whereby a number of drop core prints is made from one piece of material. The width of the stock will depend upon the thickness of the core prints and

the number required. Allowance is also to be made for the saw cuts in the separation of the prints.

At each end of the material, lay out upon each edge the shape of the width dimension of the print. Dress material to this shape; then sandpaper. The prints are more easily sandpapered in one piece than separated.

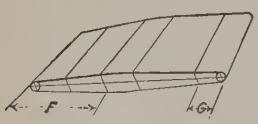


FIG. 158.—Drop core prints in process of shaping.

Saw and dress to the dimensions represented by F and G; then separate each piece into the required number of parts, and taper their face surfaces as instructed. The taper or slant is given the face surfaces of the core prints to facilitate the setting of the cores.

Fillet the corners of the pattern; then fit and attach the core prints.

Where a considerable number of drop core prints are required, their outline may be traced from a templet, then shaped by sawing and sanding.

CORE BOXES

Figure 159 illustrates the two core boxes required. To facilitate the dressing to shape of the core cavity, the depth of the box is made up of two thicknesses of material.

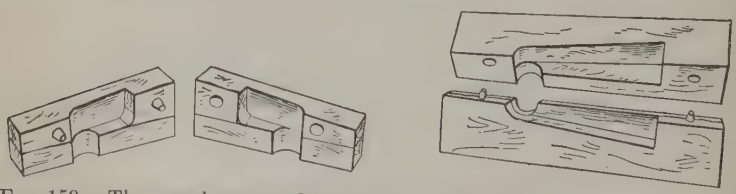


FIG. 159.—The core boxes used in forming the drop cores for the separator mold.

The slant on the face of the box is dressed after the parts are assembled and the halves doweled together. Allow about $1\frac{1}{2}$ inches of stock between the core cavity and the ends of the material and about $\frac{3}{4}$ inch between the core cavity and the sides of the material.

PATTERN 21

BRACKET

Features presented:

Attaching loose pieces

Loose dowels

Sectional layout of a core box

Shaping members that have a diminishing thickness

Figure 160 is the drawing of a cast-iron bracket.

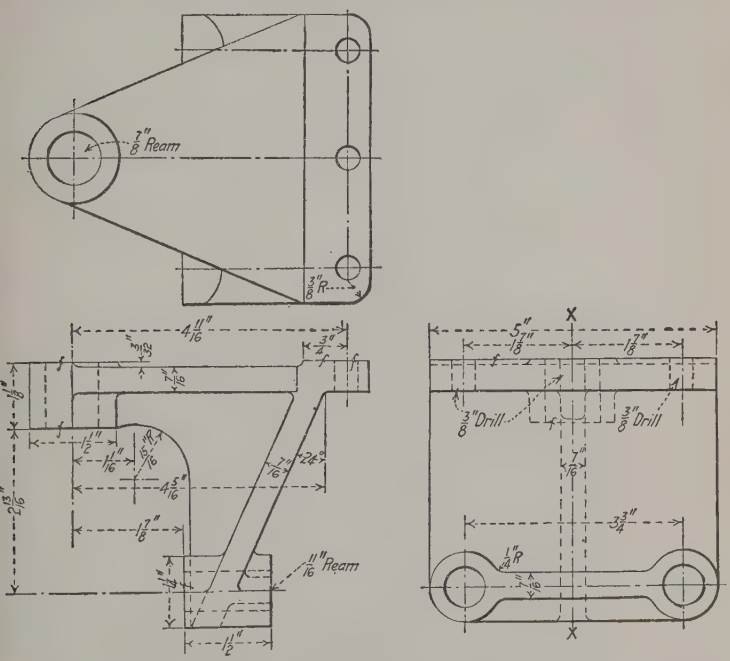


Fig. 160.

The shape of the casting suggests that the pattern be molded in the position in which it is shown (Fig. 161). The adjacent

surfaces of the web and the flange are formed by a dry-sand core; the rib-connected bosses *A* are made a loose piece.

The loose piece *A* is held in place during the early stage of the molding operation by the two protruding loose dowels *B*.

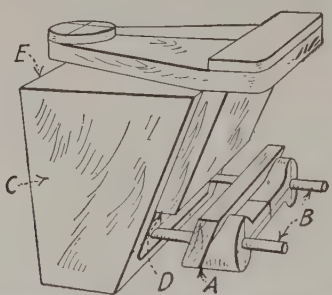


Fig. 161.—The construction of the pattern and the arrangement of the loose piece.

The loose dowels are made a sliding fit in the holes so that they may be easily withdrawn.

The pattern is molded in the usual way. When the ramming of the sand has reached the loose piece, the sand is firmly tucked about this piece and the dowel pins drawn out from the face of the core print. The ramming of the mold is then carried to completion.

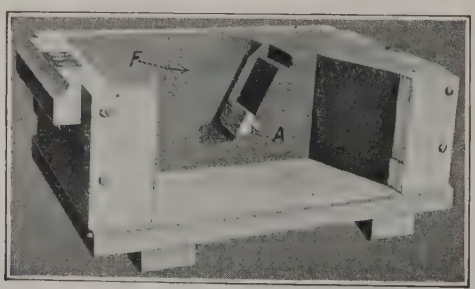


Fig. 162.—Sectional view of the drag part of the bracket mold showing the loose piece in place.

The loose piece makes it possible to draw the body of the pattern from the sand.

Figure 162 illustrates a cross section of the bracket mold; the body of the pattern has been drawn. The loose piece,

as shown at *A*, is now drawn back (picked in) into the depression left vacant by the body and taken out.

The portion of the flange to which the rib-connected bosses are attached is made a part of the loose piece. The shoulder, formed as at *D*, prevents the loose piece from being dislodged after the dowels have been removed.

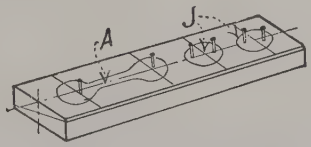


FIG. 163.—How the bosses are sawed from two attached strips whose angle of diminishing thickness is the same as the surface to which they are later attached.

The core print *C* is made to extend about ⅜ inch beyond the web and the flange. The face of the core print is made in line with the center of the boss, as at *E*.

One-half of the boss impression, as at *F* (Fig. 162), is delivered by the pattern. The other half of the boss impression is formed in the core.

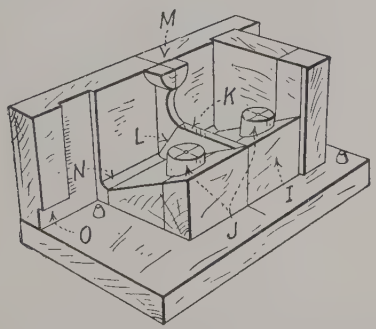


FIG. 164.—The core box required in connection with the pattern. One side and end are removed to show the interior more clearly.

An easy way to make the rib-connected bosses of the loose piece *A* of the pattern and the bosses *J* for the core box is shown in Fig. 163. Dress up a strip 14 inches long whose angle of diminishing thickness is the same as the surface to which the bosses are to be attached. Saw the strip into two

lengths, and place the lengths together as shown. This makes a piece of uniform thickness that facilitates the shaping of these members.

Figure 164 illustrates the core box. One side and one end have been removed better to show the interior of the box. Make a cross-sectional layout of the pattern along the line *XX* (Fig. 160). The cross section of the core-print portion of the pattern will be the cross section of the interior of the core box. They must agree exactly.

The core box consists of a rectangular frame, a bottom board, and a block *I*, to which are attached the bosses *J*. The rib *K* is separated along the line *L*. One portion of the rib is attached to the block. The other portion is made a part of the half boss *M* and is attached to the side of the box.

To provide stock from which to dress out the fillet *N*, a rabbet is sawed in the side of the box, as at *O*, and the strip glued to block *I*. Block *I* is attached to the bottom board. Strip *N* and block *I* can be made from the same piece of wood but are more easily and quickly made as described.

Reminders

Don't forget that dowel pins are to be set as far apart as the work will permit.

Don't set dowel pins in the drag part of a pattern.

Don't forget that loose dowel pins are to be made a sliding fit.

Don't provide bottom boards for core frames unless necessary.

Don't forget to mark all loose pieces of a pattern with the pattern number.

Don't fail to indicate with a tally mark the location of loose pieces.

Don't fail to register a core if it can be placed in a mold in any other position than that intended.

PATTERN 22

STEAM CHEST

Features presented:

Pattern and core-box construction

Figure 165 is the drawing of a cast-iron steam chest. The interior of the casting consists of a cylindrical opening through-

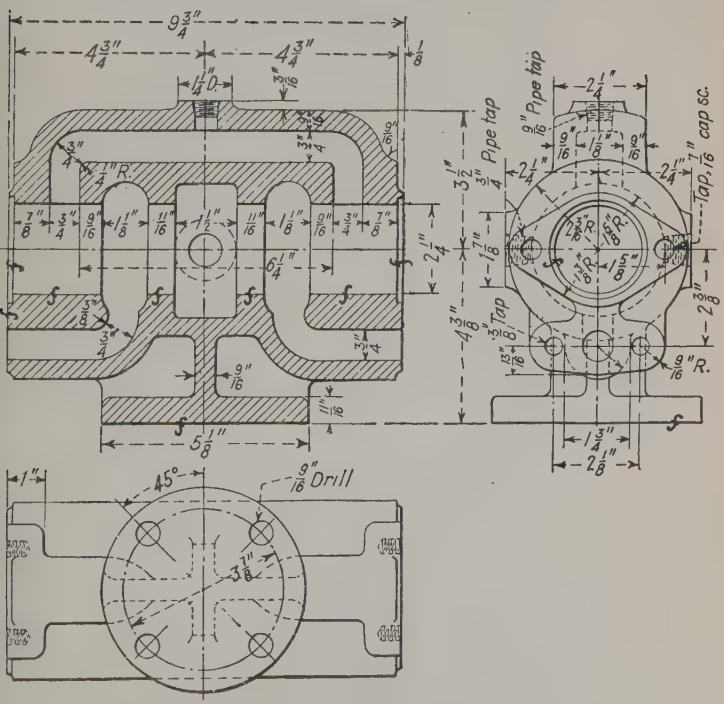


Fig. 165.

out its length. Leading off from this central opening are inlets and outlets known as *ports*. To obtain support for

the core, core prints extend out from the pattern as shown in Fig. 166. This figure illustrates the completed pattern and clearly shows its general construction.

A note on the drawing specifies that an opening upon each side of the casting is to be tapped to receive a $\frac{3}{4}$-inch pipe.

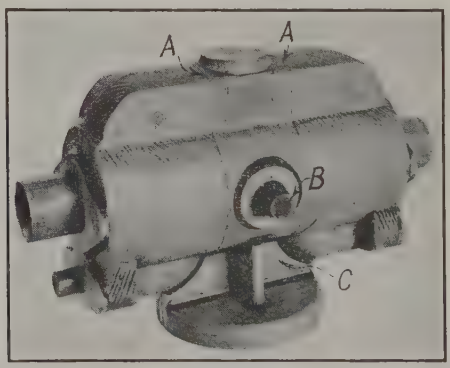


FIG. 166.—The completed pattern for the steam chest.

The support for the cores forming these openings is provided by the core prints, as at *B*. (See information pertaining to cored holes that are to be tapped to receive a pipe, page 271.)

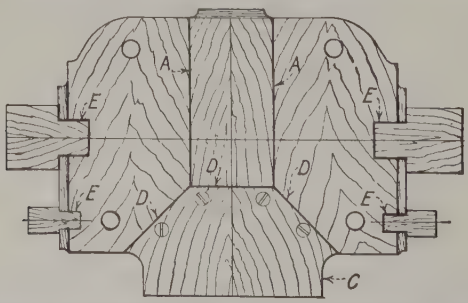


FIG. 167.—The parting surface of the pattern and the joint occurring between the various pieces of the material.

The body of pattern (core prints, facings, etc., excepted) may be practically sawed to shape. This is accomplished by getting out three pieces of material to the required cross section of the body and joining them together along the line *A*. This, of course, applies to the cope and the drag half.

Figure 167 illustrates the parting surface of the pattern. It shows the line of joints occurring between the various pieces of material. In order firmly to attach the web *C*, this piece of material is set and secured with screws into a shoulder formed in the adjoining material. The shoulder may be easily made upon the circular saw before assembling parts. Always attach small circular core prints as used in this case with a dowel, as at *E*.

CORE BOX FOR STEAM CHEST

Figure 168 illustrates the type of core box used. Since the core is symmetrical about the longitudinal center line, a box forming one-half of the core is made.

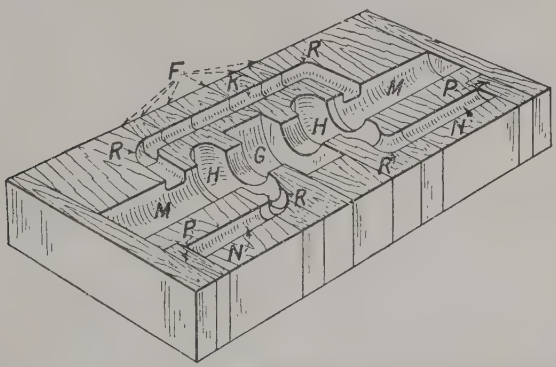


FIG. 168.—Core box used in forming the main core for steam chest.

The assembling method of core-box construction instead of carving is usually the most simple and economical and in most cases permits the maximum use of the machine tools. It should be used whenever the case will permit.

Get out all the material to an equal width, length, and of such thickness as to cause the joints to locate at the points indicated by *F* (Fig. 168). Clamp the material together, lay out the shape of the core, and proceed to cut out the cavities.

Saw and sand to shape the intake cavity *G*. Turn to shape the two exhaust-chamber cavities *H* by attaching the material to a face plate. Attach together the material con-

taining the intake and exhaust cavities *G* and *H*. The portion of the intake port *K* extending across this material is now sawed out by passing it over the circular saw.

The cavities *M* and *N* in the end pieces are roughed out on the saw and finished in the usual way. Note how the exhaust-port cavities *N* are dressed out to the full width of the end pieces and the corners of the pieces cut out and the blocks *P* nailed in. The turns as at *R* of the intake and exhaust ports are gouged out after all parts have been attached together.

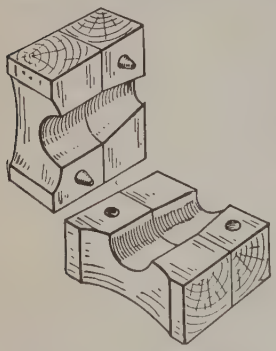


Fig. 169.—Core box for the pipe-connection openings.

Figure 169 illustrates the core box used in forming the hole in each side of the casting for the ¾-inch pipe connection. Attention is called to the way in which one surface of the box is made in the form of an arc. This arc is made to correspond to the circumference of the main core so that the two cores will form a close union.

RAPPING AND DRAWING PLATES

All patterns that are used to any extent should be provided with rapping and drawing plates. Such plates not only facilitate the drawing out of the pattern but greatly add to its period of usefulness. If a pattern is not provided with these plates, the molder must use a draw spike for the rapping and the drawing operations. A continuance of this method will not only deface the pattern but in a short time ruin it. To prevent this rough usage, rapping and drawing plates are set into the parting surface and fastened with screws.

Rapping and drawing plates of various designs may be obtained through any pattern-supply house.

PATTERN 23

ROCKER ARM

Features presented:

- The cover core
- A temporary or false cope
- Laminated construction
- Core-box arrangement

Figure 170 is the drawing of a cast-iron rocker arm.

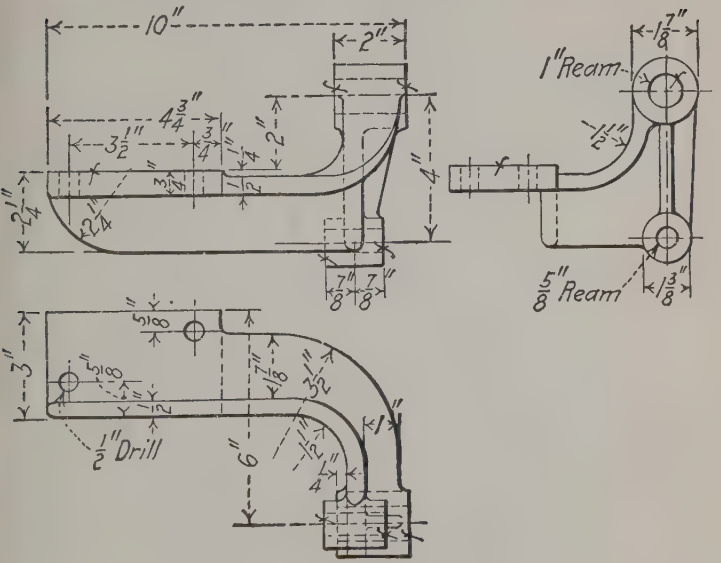


FIG. 170.

Although the design of many castings will afford an alternative position for molding the pattern, the shape of the rocker arm offers no other logical choice than the arrangement of the pattern as to be herewith discussed.

The molding position of the pattern is represented by the side and end views of the casting as shown in the drawing. This position in the mold will require the use of what is commonly termed a *cover core*. As its name would suggest, it is a core used to cover or close an imprint that has been left by

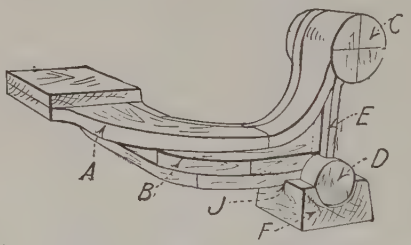


FIG. 171.—Structural features of the bracket pattern.

the drawing out of a loose part of the pattern in the course of ramming the mold.

The pattern is made up, as shown in Fig. 171, of a flange *A*, member *B*, bosses *C* and *D*, and the rib *E*. Designated by *F* is the loose core print that forms the seat for the cover core.

Since the shape of the cope surface of the pattern is such that it will not well permit this face to be laid upon a molding

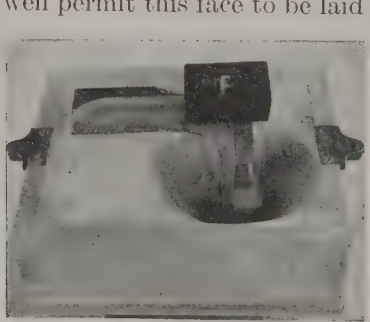


FIG. 172.—The completed false cope.

board for the ramming of the drag, the making of what is termed a *temporary* or *false cope*, as shown in Fig. 172, is resorted to. This work consists of filling the cope section of the flask with loose sand and forcing the pattern down to about the desired position. Then while the pattern is held in this

position, the sand is tucked and rammed about it and a parting surface made along the edge of the top surface of the flange *A* and over the top of the boss *C* to a point opposite its axis.

Figure 172 illustrates the false cope completed and ready for the placing on and the ramming up of the drag section.

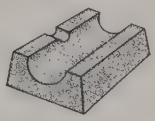


FIG. 173.—The cover core.

When the height of the sand during this operation has reached the top of the core print *F*, the print with its attached boss *D* is drawn out and the core shown in Fig. 173 set into the seat thus formed. From here on the drag is rammed up in the usual way and the mold rolled over. Upon the removal and

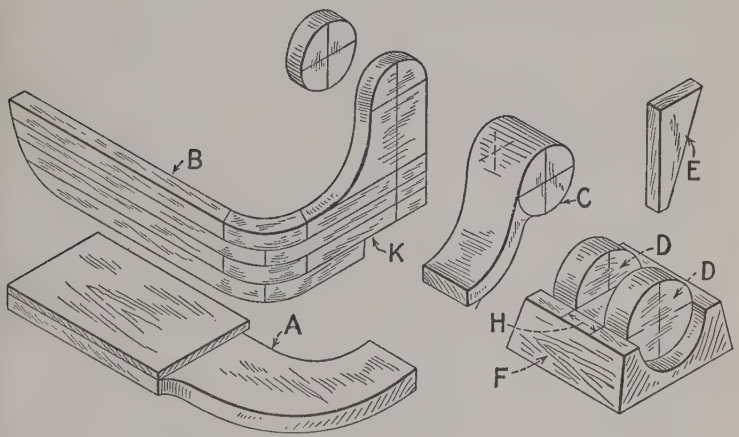


FIG. 174.—Component parts of the pattern.

shaking out of the sand from the false cope, this section of the flask is returned to place upon the drag and the work carried to completion.

Illustrated in Fig. 174 are the various members of the pattern dressed to shape and ready to be assembled. The core print *F* consists of a block containing a semicylindrical cavity, within

which is attached the boss *D*. Instead of cutting out the member *B* so as to conform to the circumference of the boss *D*, the boss is cut out as at *H*. To bring the face surfaces of the core print in line with the axis of boss *D*, the member *B* is cut out as at *J*. This arrangement permits the divided boss, as shown, to slip over member *B* and is thereby the means of registering the core print in place.

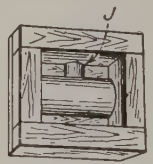


Fig. 175.—The core box for the cover core.

Designated by *J*, in the illustration of the core box (Fig. 175) is a piece corresponding in size and shape to that removed from the member *B* as at *K*. Ordinarily the practice, as previously described, would be to separate the frame from the bottom board of the box. However, due to the liberal amount of slant given to the walls of the box, it will lift from the core without interference.

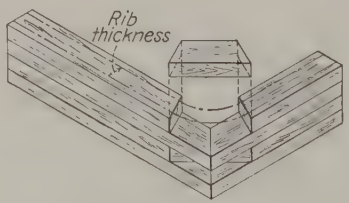


Fig. 176.—Laminated construction of member *B*.

For irregular-shaped ribs and kindred members, the maximum degree of strength of the material is obtained through the use of laminated construction. This work consists of stacking and gluing together, as shown in Fig. 176, a number of layers of wood. The strength of a member so made will be in proportion to the number of layers and the relative position of their abutting end surfaces (see segmental construction, page 296).

PATTERN 24

GEAR CASE

Features presented:

Coring out a casting in order to strengthen a pattern

Core-box construction

Figure 177 is the drawing of a brass gear case

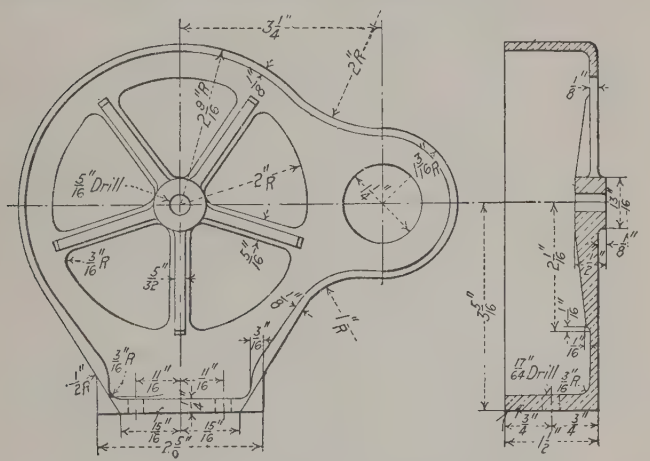


Fig. 177.

Interior and exterior surfaces of castings whose pattern would easily deliver its impression in the sand are frequently formed by dry-sand cores for the sake of the added strength given the pattern.

If the pattern for the gear case shown were made to deliver the impression of its interior surfaces, it would be so fragile that it could not withstand foundry usage.

Figure 178 illustrates how the pattern is made solid, the interior of the casting being formed by a dry-sand core.

The depth of the pattern is made up of three thicknesses of material. Thickness *A* represents the core print, which is made ¼ inch; *B*, the depth of the interior of the casting; and *C*, the web thickness.

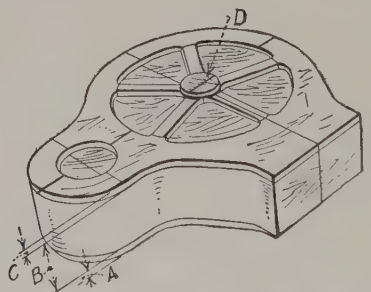


FIG. 178.—The construction of the gear-case pattern.

The spider *D* is not cut out of the web thickness but made independent and then attached.

Figure 179 illustrates the core box. It consists of a frame and bottom board of the usual construction. The frame is

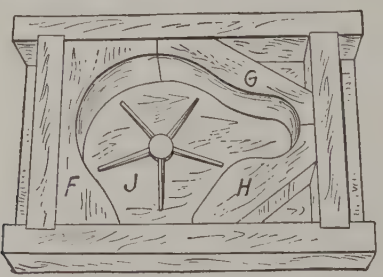


FIG. 179.—The construction of the core box supplementing the gear-case pattern.

filled in with the necessary loose material *F*, *G*, and *H*, to produce the required shape of the core cavity. The pieces *F*, *G*, and *H* are fitted into place, then the shape of the core cavity laid out.

The pieces are dropped into place, the ramming in of the sand forcing them back into their correct position. The boss and the ribs indicated by *J* are attached to the bottom board.

This construction is particularly adapted to shaping cores that have projections occurring upon the walls of the core cavity at a point above the bottom board.

The location of the pieces in their relation to the frame is to be plainly indicated. The use of the loose pieces does not permit the use of fillets; therefore the box is to indicate where filleted corners of the casting are required. Refer to the information on the marking of loose pattern parts given with pattern 18, page 144.

In the case of right- and left-hand cores of greater proportions, this type of box is used to advantage in the saving of time and material, for the frame and the bottom board may be employed in the making of both cores.

A core box of this type requires no draft and little if any rapping to remove it from the core.

QUESTIONS

1. What is the purpose of placing tie pieces in patterns?
2. How does a tie piece prevent the distortion of a casting?
3. When is a tie piece stopped off?
4. Of what does the operation stopping off consist?
5. Describe the nature and use of a cornering tool.
6. What is a struck fillet?
7. When are drop core prints used?
8. What is the special feature of drop core prints?
9. Name two functions that drop cores perform.
10. What construction feature was learned from the steamchest?
11. Define the term *loose piece* as applied to pattern work.
12. With what are loose pieces usually attached?
13. What pattern dimension may not permit the use of a loose piece?
14. Describe how a loose piece of a pattern is molded.
15. What is the purpose of rapping and drawing plates?
16. How is a cover core used with the rocker-arm pattern?
17. Why was the rocker-arm cover core box made solid?
18. What is the purpose of making a false cope?
19. What is understood by laminated construction?
20. What two features of laminated construction will give the maximum degree of strength?
21. Why was a dry-sand core used in making the gear case?
22. What particular feature was presented by the gear-case core box?

PATTERN 25

LINK BELT GUARD

Features presented:

- Follow boards
- Pattern construction
- Molding procedure

Figure 180 is the drawing of an aluminum safety guard.

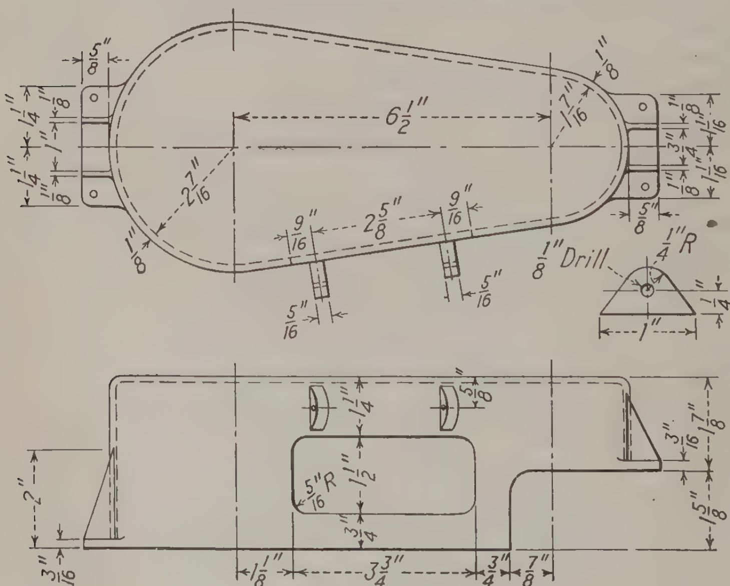


Fig. 180.—Link belt case.

This design of casting was selected to show that a pattern of a thin shell nature may be built around and molded while being supported upon a form, as shown in Fig. 181. Such an arrangement not only prevents the distortion of the pattern but also provides the parting surface of the mold.

By making the door hinge ears a part of the loose piece *A*, these members will retain their correct position and can be readily withdrawn from the sand.

In making the mold it is advantageous to lift the pattern from the core with the cope, instead of lifting the core out of the pattern. The former procedure of molding will require that the cope be rammed up before the drag and the mold rolled over to pouring position. Material *B* forms an offset

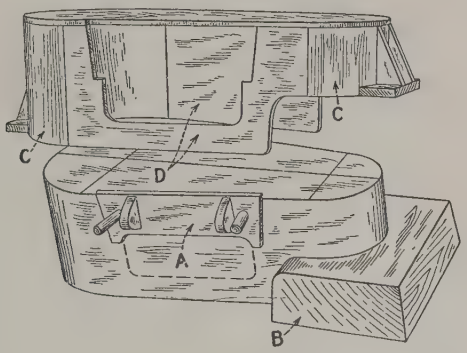


FIG. 181.—The pattern and the follow-board form.

in the parting surface, which is made necessary by the shortening of the side-wall members.

Forms of this type are to be given the maximum degree of draft allowable upon their side surfaces. To prevent the glue from adhering to the form, the surfaces are to be well shellacked and lightly greased.

Length grain wood is easily worked and will also give the maximum strength to the circular walls *C*. These sections are to be shaped and secured in place before the side-wall material *D* is attached. In getting out the fragile sections *C*, it is a good practice to fit this material in place upon the form. Blocks are then made to fit these concave surfaces, to which the material is spot-glued for the final sawing and dressing operation.

PATTERN 26

FRAME

Features presented:

Match boards

Pattern arrangement

Figure 182 is the drawing of a brass door frame.

Patterns of this nature when made of wood will not survive many operations of molding and are frequently built into the body of a match board or plate, as shown in Fig. 183.

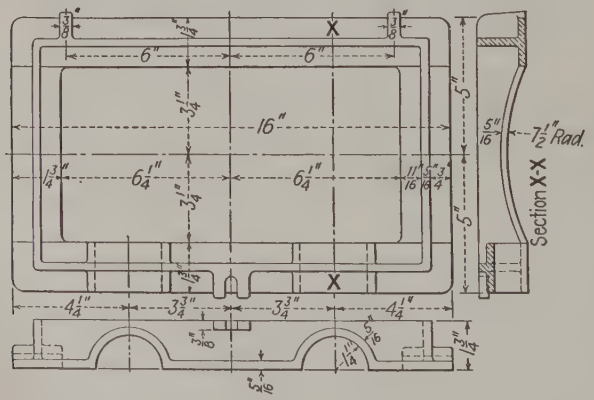


Fig. 182.

In order to show clearly the arrangement of the work, the board is shown in the reverse position to that of its molding. Sectional views are presented in the illustration by showing in the foreground a portion of the board removed.

To produce in the mold the cavities which are to form the curvatures of the side and end flanges of the frame, core print-like forms, as shown at *A* and *C*, are attached within and with-

out the pattern. In the opposite surface of the board, and directly beneath *A* and *C*, are carved out correspondingly shaped depressions, designated as *B* and *D*. These depressions are to form projecting bodies of sand, which upon the closing of the mold will enter and close off the indentations left by the printlike forms *A* and *C*.

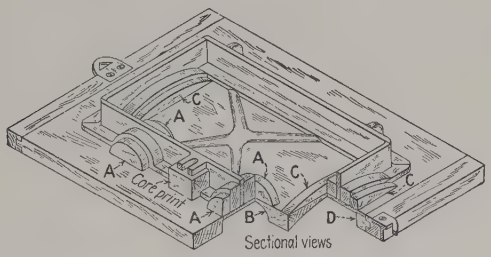


FIG. 183.—The pattern-board arrangement.

Wood is not the most dependable material for this work and for this reason aluminum plates are chiefly used. Complete match plates may be cast directly from the pattern of an object through a comparatively simple molding operation.

Triangular-shaped pins, which engage the end plates of the

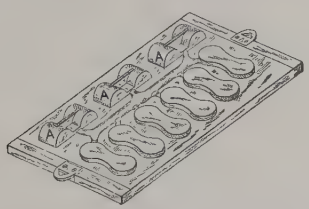


FIG. 184.—Another example of pattern-board application.

board, cause it to register correctly between the drag and the cope.

A universal method employed to increase production is to mount upon a board or plate, as shown in Fig. 184, a series of patterns and their gate forms. The servicing of the metal to all the mold cavities is then done through a centrally located sprue. Not only will this arrangement increase the output

but patterns so mounted will survive those unmounted and their castings will be found more uniform.

Whenever the form of a casting recommends that the pattern be parted as in the case of the link pattern and designated as *A*, Fig. 184, the drag and the cope halves of the pattern are separated by the board. The cope halves, if necessary, are attached in place with dowel pins so that these parts will remain in the sand and be lifted off by the removal of this section of the flask.

In order to make the cope halves of the patterns interchangeable upon the board and therefore expedite their replacement, the relative position of the dowel pins in each cope half must agree exactly.

The duplication of the position of a related series of bored holes for dowel pins is best accomplished through the use of a jig.

Unless every precautionary measure is taken to further the exact location of the cope half of the pattern directly over that of the drag half, a discrepancy is very apt to occur in their positions. The occurrence of such error will be evident in the resulting casting.

The construction of the board is of the conventional tongued and grooved, pine, maple cleated, drawing board type of about 1 inch in thickness.

PATTERN 27

YOKE PAN

Features presented:

Pattern arrangement

The cap core

Core registering locks

Figure 185 is the drawing of a cast-iron yoke pan.

The casting consists of a pan-shaped base supporting a yoke bracket member. In considering the molding possibilities of the pattern, two alternatives are presented. One of these

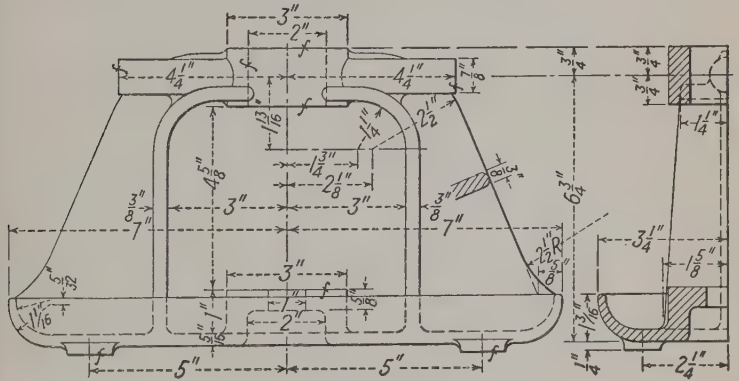


Fig. 185.

procedures would be to part the pattern along the longitudinal center line or through the middle of the web of the yoke. This molding position would require that a core print be made to extend about 1¼ inch above the edge of the pan and the interior surface of this member formed by a dry-sand core. While this arrangement would perhaps make a more durable pattern, its alternative procedure, which is the one to be discussed, will produce good results.

This work would require the making of the complete pan pattern and also the portion of the two vertical yoke members, which are shown in full lines within the assembled cap core as outlined in Fig. 186.

Cap core is the term commonly applied to that arrangement of core or cores which are to be set upon a pattern and thereby

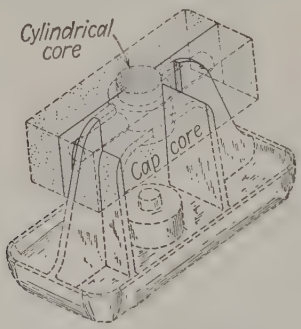


Fig. 186.—Setup of the pattern with core in place.

will complete a portion of the mold that is not given shape by the pattern proper. That portion of the yoke pan mold cavity as furnished by the cap core is shown in broken lines (Fig. 186).

Attention is called to Fig. 187, which shows the arrangement of the joint surface between the web of the pan and the

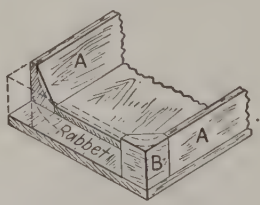


Fig. 187.—Joint arrangement of the pan material.

material forming the edging. By using the rabbet joint feature, the feather edge that would otherwise occur along the edge of the fillet is avoided. In gluing up this work it will be found more expeditious if the material *A* is attached before the blocks *B*.

The core-box provision required for forming a pair of cores

is shown in Fig. 188. The setup consists of attaching within a frame a facsimile of that portion of the pattern required to produce the mold cavity to be furnished by the cap core. Since the box is made reversible on its transverse center line, it will serve for a pair of cores. The impressions made by the core prints *C* are to locate and secure in place the cylindrical core that is to form the interior of the boss.

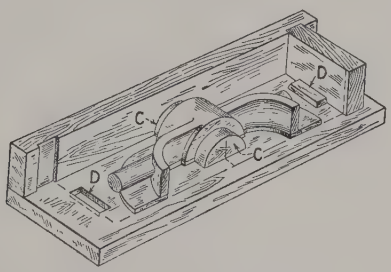


FIG. 188.—Core box required for the yoke-pan pattern.

So that a pair of cores will correctly register and retain this relation, core locks are formed upon their joint surfaces. The locks in this instance are in the form of a pair of rectangular offset surfaces provided in the box, as at *D*. Whenever it is deemed necessary, the union of pasted cores may be further bonded by wiring.

A core made from the box shown in Fig. 189 forms the interior of the boss at the bottom of the pan.

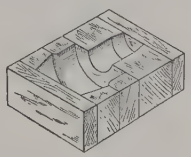


FIG. 189.—Core box for the core forming the interior of the pan boss.

Molding of the pattern is begun in the customary way and pursued until the sand has reached a point slightly below the position of the cap core. At this point the core is set and held in position while the sand is tucked and rammed about it. From this point on the making of the mold will follow the usual procedure.

PATTERN 28

SHIELD PLATE

Features presented:

✓Lag and stave construction

✓Batten foundations and headings

The round-soled plane

Figure 190 is the drawing of a cast-steel shield plate.

It is the intention of this example of pattern work to show comparatively narrow strips (lags) may be fastened about batten foundation members that are so shaped as to follow

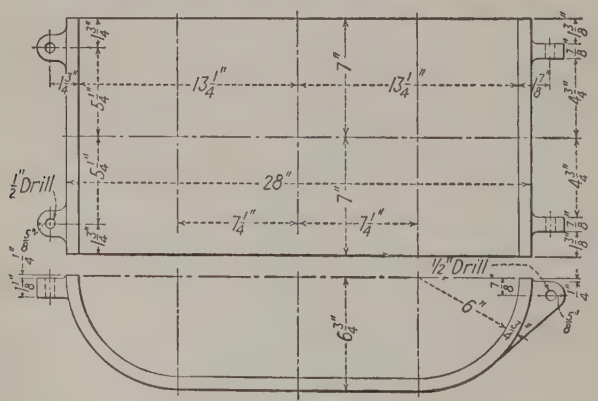


Fig. 190.

approximately a line parallel to the contour of the surface of the casting. The lags are made of a narrow width so that, when they are attached to the foundations, they will closely conform to the required outline of the pattern. This form of building will then require the minimum amount of waste to be removed in order to produce the required shape or thickness of a curved plate member.

Since the durability of the pattern will largely depend upon the firmness of the battens *A*, as shown in Fig. 191, they are to be of a laminated nature, or made by attaching the end segments to the beam section with a half-lap joint.

While the pattern can be molded with the battens downward, it is most likely that the average molder would prefer to cope out the inside. This position will require that ample taper be given the side surfaces of the battens so that they will not interfere with the lifting off of the cope. This should not occur if a slant of $\frac{3}{8}$ inch to 3 inches in height is allowed.

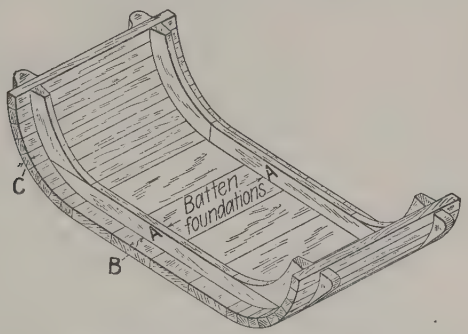


FIG. 191.—Structural features of the shield-plate pattern.

For the laying down of the lags, the battens are placed in correct alignment and temporarily attached to a level surface. Allow, as shown at *B*, about $2\frac{1}{2}$ inches of the material to extend beyond the battens.

Determine from a partial layout the width, the thickness of the material, and the angle of the abutting edge surfaces of the lags. If the angles of the edge surfaces are carefully sawed, they should need no further joining, but the lags will, however, require concaving, as shown at *C* (Fig. 192). This operation is done with the aid of a round-soled plane as shown.

The Round-soled Plane.—Round-soled planes are designed and constructed for the purpose of shaping concave surfaces. Because of the interchangeable soles *D*, which are of different radii, many degrees of concavities may be produced. Good

results may also be obtained by attaching with screws a wooden sole to a jack plane and then dressing it to the desired curvature. The plane iron is then ground accordingly.

Begin the assembling of the lags from the ends of the battens and check, at frequent intervals, the width of the built-up surface to see that it proceeds parallel. At the completion of this work, the end surfaces are dressed and the required thickness gaged thereupon.

To indicate that the battens are not to be a part of the desired casting and therefore their depressions in the mold are to be stopped off, the battens are to be marked with broad

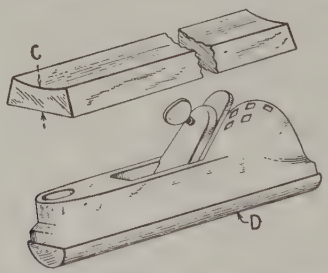


FIG. 192.—The round-soled plane used in concaving the lags.

diagonal stripes of a color contrasting with that of the pattern proper (see stopping off, page 146).

Stave Construction.—When long cylindrical or conical-shaped bodies exceed 8 or 10 inches in diameter, they are usually built up of stave construction. This feature gives not only a light strong pattern but one more likely to retain its dimensional form than if made solid. The most common practice is to join the staves and attach them to heads as shown in Fig. 193. The number of staves will depend somewhat upon the diameter of the work, while their thickness will be governed by the strength desired. To stiffen the construction as well as to provide means for rapping and drawing the pattern, the bar *K* is let into the heads as shown. The number of heads will depend somewhat upon the thickness of the stave material.

If the structure is made up of a polygon of many sides the

thickness of the staves may be decreased. For the ordinary run of work, material of 1-inch thickness will be found suitable. To determine the number of staves to be used, scribe a semicircumference of the work as shown in Fig. 194. From the table of polygons select a tentative stave width and divide the semicircumference into this number of equal parts, and scribe the line *AA*, which represents the greatest chord of one of the parts. Lay off the distance *B*, which is the amount of waste to be turned off at this point; then scribe parallel to *AA* the line *CC*, representing the outer face of the stave. From the line *CC* lay off the distance *D*, which represents the thickness

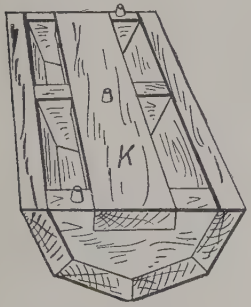


Fig. 193.—Application of stave construction to cylindrical bodies.

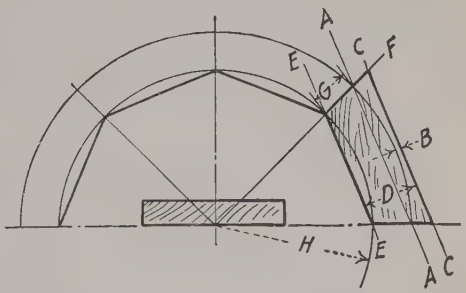


Fig. 194.—The layout for determining the thickness and number of staves required.

of the stave material; then scribe the line *EE* and the radial line *F*. The area enclosed by the lines represents the cross section of the stave. If the abutting edges *G* of the staves are too thin, select a greater number of staves and repeat the laying-out operation.

The thickness of the heads should be about $1\frac{1}{2}$ times the thickness of the staves. Lay out one head and accurately saw it to shape. It is then used as a templet in tracing the outline of the others upon the material. The heads are attached to the bar *K*; then the dowels are set and the staves fastened in place. By tilting the saw table to the required angle the beveled edges of the staves may be sawed to shape and thereby need no further work to fit them together. Any slight distor-

tion that is likely to occur can usually be overcome by the use of pinch dogs.

If it is desired to make the heads of circular form, instead of polygon form, the face of the staves is made concave, the concaving being done by passing the material over a circular saw at an angle, as shown in Fig. 195. To obtain the angle that the gage is set to the axis of the saw, raise the blade to the required height above the table. Brad together a light frame whose inside width is equal to that of the narrow face of the staves. Place the frame over the saw and swing it around until one of the edges comes in contact with the point

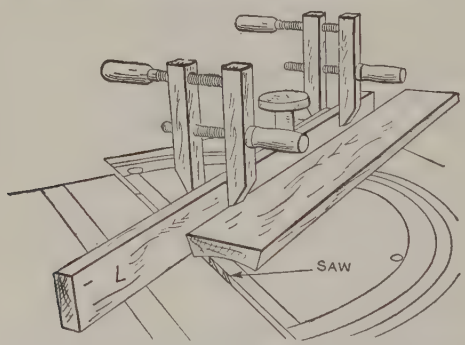


Fig. 195.—The arrangement of the guide for concaving the face of staves upon the circular saw.

of a tooth at the back of the saw and the other edge contacts a tooth point at the front of the saw. Hold the frame in this position and trace the angle of its enclosed width upon the surface of the table. Set the gage *L*, as shown, in front of the saw and to this angle; then move it back to a distance equal to the overhang of the bevel on the edges of the staves. A smoother surface will be produced if the waste is removed by two operations. The saw should be sharp and well set and the material fed over the saw slowly.

For the staving up of semicircular cavities, the same principle of construction is involved as for a staved up cylindrical body, except that it is the reverse, as shown in Fig. 196. In this case, the inside faces of the staves are dressed to shape

and the outside faces attached to the heads as shown. The heads are laid out in the same manner as for a cylindrical body, except that instead of working from the outside diameter, the number of staves and their cross sections are found from the inside diameter of the cavity. The heads are attached together by the bars *M*, then the staves fastened in place. The surface of semicircular cavities built up of staves is usually finished with a core-box machine or core-box plane. Whenever the

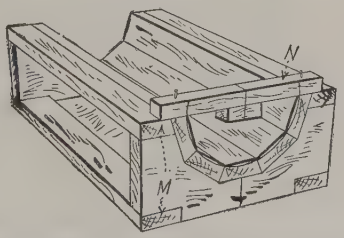


FIG. 196.—Application of stave construction to semicircular cavities.

surplus waste has been removed from the staves with a circular saw as described, the soled plane is used for finishing the surface.

TABLE OF POLYGONS

A	B	A	B	A	B	A	B
		7	2.31	13	4.18	19	6.07
		8	2.61	14	4.49	20	6.39
3	1.16	9	2.93	15	4.81	21	6.71
4	1.41	10	3.24	16	5.12	22	7.03
5	1.70	11	3.55	17	5.44	23	7.34
6	2.0	12	3.86	18	5.76	24	7.66

By means of the table above, regular polygons having any number of sides from 3 to 24 may be easily drawn. The quantities in the columns headed *A* are the number of sides required to a circle. To obtain the length of a side of any circle, divide the diameter of the circle by the quantity in column *B*. By reversing the process the diameter of the circle is obtained from the length of a side.

PATTERN 29

RETORT COVER

Features presented:

Skeletonized patterns

Molding practice

Core frame construction

Figure 197 is the drawing of a cast-iron retort cover.

Skeletonized patterns, while of a comparatively inexpensive nature when compared to the cost of the material and labor incurred in the construction of a complete pattern, also have

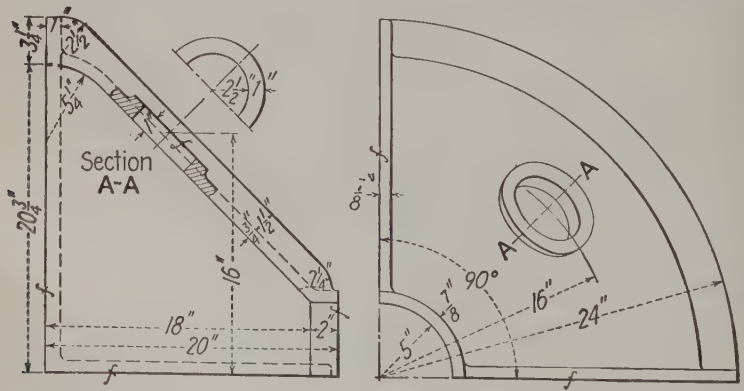


Fig. 197.

their molding advantages. However, it must be added that, by reducing the pattern expense to a minimum, the molding cost is likely to be increased.

As the name would suggest, it is not a complete pattern but of such frame and rib construction that it will form a partial interior and exterior outline of the required casting. By this arrangement the ribs establish guiding surfaces to be followed

in completing the contour of the mold cavity. The framework can be made more or less elaborate according to the wish of the molder, upon whose ability the uniformity of the metal

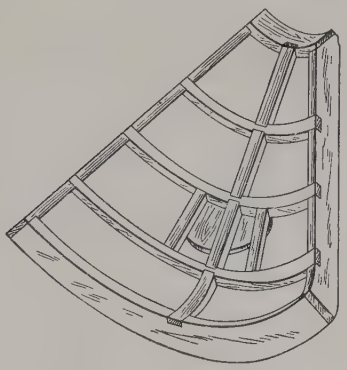


FIG. 198.—The completed pattern.

thickness of the casting will largely depend. It is the type of pattern chiefly employed in the production of large hollow or shell-like castings. Hence, the size and nature of the retort cover would suggest the use of a skeletonized pattern as shown

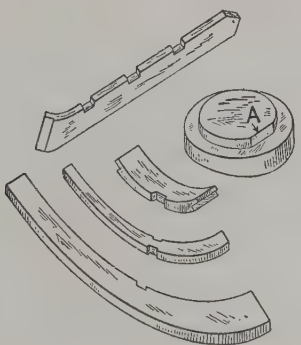


FIG. 199.—Foundation members.

in Fig. 198. Its molding position would likely be a matter of choice.

From a radial section layout of the pattern the foundation members as shown in Fig. 199 are outlined. When these

component parts are accurately sawed to shape, there is no reason why they cannot be assembled without further dressing. The conical surface of the flange pad is shaped with the aid of the circular saw and round-soled plane, then sawed to its circular form. Since the core forming the hole through the pad can be easily misplaced within the mold, its position is to be registered by flattening the core print as at *A*.

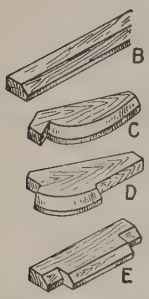


Fig. 200.—The strickles.

In the making of the mold, the pattern is embedded and the drag rammed up and its interior surface completed with the aid of the strickles *B* and *C* (Fig. 200). Following the ramming up and the removal of the cope, the strickles *D* and *E* are used in removing the sand that lies between the ribs. The pattern is then taken out and the dressing of the mold carried to completion.

Many large cores whose shapes will afford a flat surface

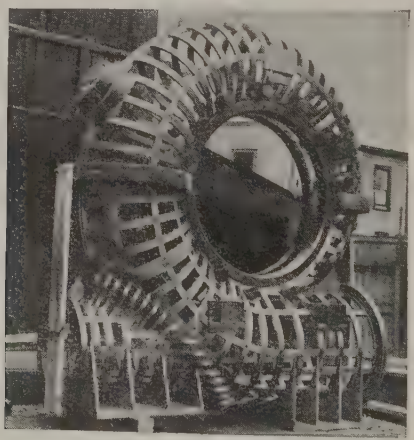


Fig. 201.—A large skeletonized pattern.

upon which the sand bodies may lie for baking can be economically formed within a skeleton or frame setup.

A large and typical example of skeletonized pattern work is illustrated in Fig. 201.

PATTERN 30

CAGE

Features presented:

✓ Molds made of dry-sand bodies

✓ Contraction of magnesium

Core frame setups

The regripping of wood screws

Figure 202 is the drawing of a magnesium cage casting.

This design of casting was selected that it might be shown how molds made up of a series of dry-sand bodies may be used

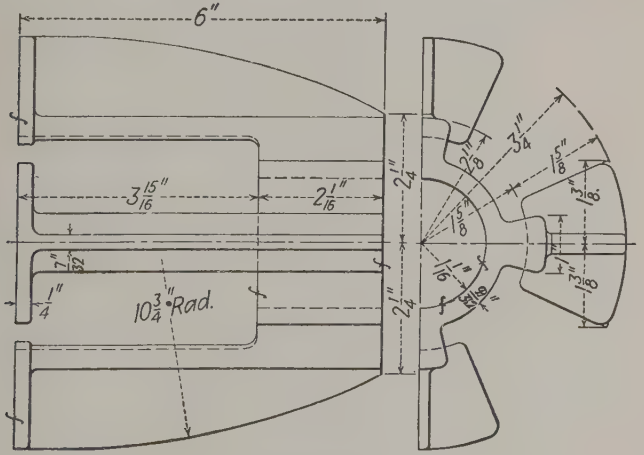


Fig. 202.

to a distinct advantage in the production of many types of nonferrous or other cast metal objects. Whether this practice be employed in the making of large or small molds, the procedure is practically the same.

The work involves the forming of the impression of a pat-

tern or the sectional part of a pattern in core-sand bodies, which are then baked and subsequently assembled into a mold unit for pouring.

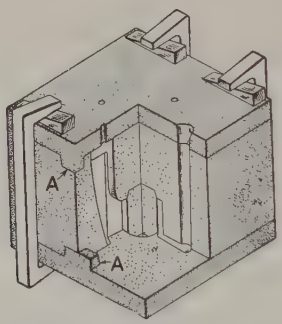


Fig. 203.—A diagrammatic sectional view of the cage mold.

Shown in sectional views (Fig. 203) is an illustration of the 4 core-sand bodies which make up the mold for the cage casting. To assure the correct assembling of the sand bodies,

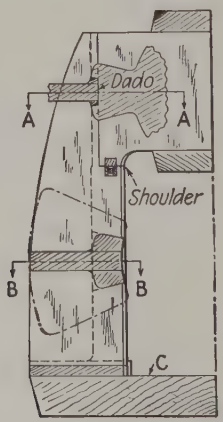


Fig. 204.—Three sectional views of the cage pattern.

registering surfaces or locks, as shown at *A*, are provided upon their contacting surfaces. The gate arrangement as shown is figuratively used and is not in accord with magnesium casting practice and is here presented only as an illustrative feature.

The arrangement of the pattern as given in three sectional views (Fig. 204) will show it to be divided into five parts and to consist of a central body and four supporting members. By the joining of the members with a dado joint and forming a shoulder, as shown by the radial sections, it will permit the four supporting members to be drawn out in the opposite direction to that of the central body. To maintain the four supports rigidly in their correct relation, as well as to facilitate their withdrawal in one operation, the members are attached to the disk *C*, which is set into the bottom board of the frame as shown in Fig. 205.

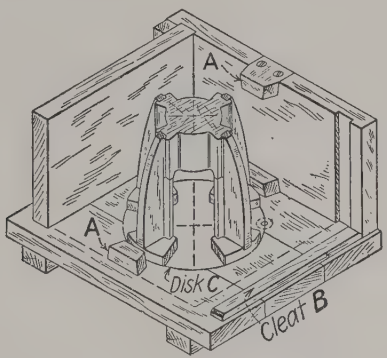


FIG. 205.—Frame setup with the cage pattern in place for making the cheek section of the mold.

Illustrated in Fig. 205 is the frame setup with the pattern in place for the making of the body of cheek section. Since the frame is parted diagonally, the registering surface forms, as at *A*, can be permanently attached at the locations shown. The cleats, as designated by *B*, are the means of locating and securing the frame upon the bottom board. The procedure to be followed in the making of this section of the mold is to ram up the pattern in the position shown. The central body of the pattern is then withdrawn and the work rolled over for the removal of the four supporting members.

Illustrated in Fig. 206 is a figurative illustration of the frame setup for the foundation or drag section of the mold. Attached

to the bottom board is the core print A and the gate form B. The depression which forms the projecting registering surfaces is shown at C. If desired, the same frame may be used for making the cope section of the mold by alternating the

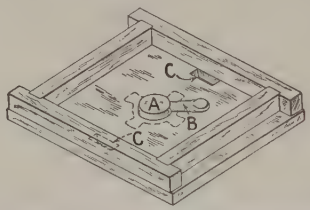


Fig. 206.—Frame setup for making the drag section of the mold.

core print A and the gate form B with that of the runner. The latter is not shown.

Of the three methods generally employed in securing together the open corners of core frames, screws are perhaps less injurious than dogs or clamps. However, screws that are driven parallel with the grain of most woods will cut the

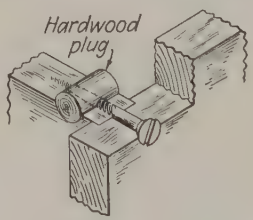


Fig. 207.—Regripping of wood screws.

grain, which will eventually cause the screw to lose its withdrawal resistance. This condition can be readily overcome by the insertion of a hardwood plug, as shown in Fig. 207. At the completion of the usefulness of the plug it is driven out and a replacement made.

PATTERN 31

SWIVELED HOOK

Features presented:

✓Intercasting of linked members

Providing freeness between closely joined linked members

Pattern requirements

Core-box setup

Figure 208 is the drawing of a cast-steel swiveled hook.

The casting of these linked members involves two molding operations. First, the casting of the hook and, second, the casting of the swivel about the shank of the hook.

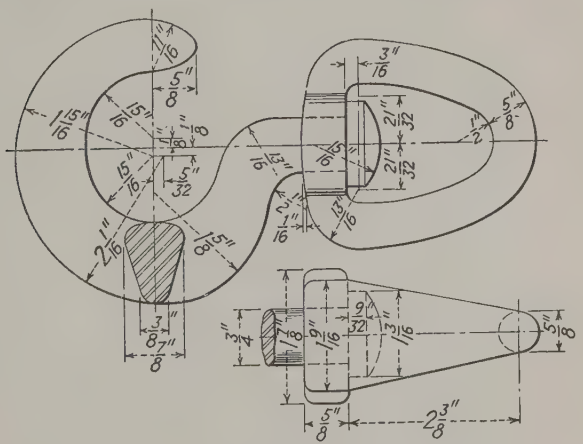


FIG. 208.

In the intercasting of this combination the molten metal will come in contact with the shank and the head of the pre-cast hook. To protect these surfaces, which are exposed to the hot metal, as well as to provide a freeness of action between

the parts, the surfaces as designated at *A* (Fig. 209) are to be relieved of all roughness and given a coating of sand. This is accomplished by applying core oil to the surfaces and sprinkling over this area a fine grade of silica sand and subjecting it to oven drying. By repeating this operation, a coating of

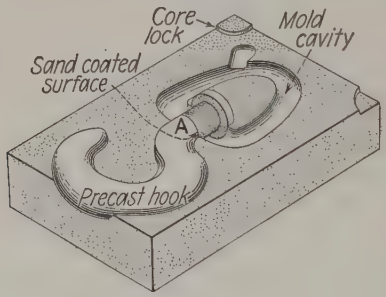


Fig. 209.—Drag core with precast hook in place.

a sufficient degree of thickness may be built up to meet the demand.

Illustrated in Fig. 209 is the drag core of the mold with the precast hook in place. Since core locks are provided only at

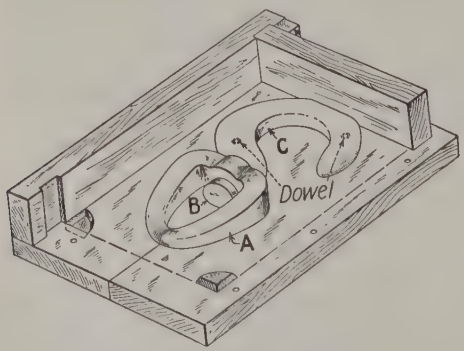


Fig. 210.—The core-box setup for the swiveled hook.

one end of the cores, the lining up of the opposite ends will be governed by the correct registering of the hook within the cores. It is therefore of the utmost importance that the hook should fit snugly into its seat depressions.

If the walls of the box arrangement as shown in Fig. 210 are given ample draft allowance, the setup can be of solid construction, and the swivel pattern *A* and the head *B* permanently attached to the bottom board. Since the box is

FIG. 211.—Assembling a large dry-sand mold.

made to reverse upon its center lines, a pair of cores can be made by alternating the half seat forms of the hook portion *C* and the riser and runner gate forms. The latter are not shown.

The assembling of the dry-sand component parts of a large water turbine mold is shown in Fig. 211.

QUESTIONS

1. State the twofold purpose of a follow board.
2. Why did the belt guard pattern require a follow board?
3. How did a follow board aid in making the belt guard pattern?
4. Why were the door ears of guard pattern attached as explained?
5. How did the molding of the guard pattern differ from standard practice?
6. State means used to prevent glue from adhering to a surface.
7. What is the contraction allowance per foot for aluminum?
8. What is the purpose of spot-gluing material together?
9. What was the special feature presented by the frame pattern?
10. When is the use of metal match plates advisable?
11. How may match plates be arranged so as to increase production?
12. Define a cap core as related to foundry practice.
13. Describe two molding possibilities for the yoke pan pattern.
14. What is the purpose of core registering locks?
15. Briefly describe the use of a cap core.
16. What is lag construction as used in pattern work?
17. What is meant by foundation members or battens?
18. Why are lags made of a comparatively narrow width?
19. How were the foundation battens of the shield pattern made?
20. What marking is used to designate a batten member?
21. What means prevent a batten from becoming a part of the casting?
22. For what purpose is a round-soled plane used?
23. How may a jack plane be used as a soled plane?
24. What type of construction is chiefly used for large cylindrical bodies?
25. What advantage have staved-up bodies over solid bodies?
26. What is to be understood by the term *heading members?*
27. How should the thickness of heading and stave material agree?
28. Describe the procedure followed in duplicating headings.
29. How may the concaving of staves be done upon a circular saw?
30. What is a skeletonized pattern?
31. For what nature of castings are skeleton patterns usually used?
32. What chief advantage is gained from a skeleton pattern?
33. How is a skeleton pattern used in making the shield mold?
34. For what purpose is a strickle used?
35. Define a mold made up of dry-sand bodies.
36. How are the parts of a dry-sand (core-made) mold formed?
37. What feature assures the registering of dry-sand bodies?
38. What new pattern feature was presented by the cage casting?
39. What is the contraction allowance per foot for magnesium?
40. How may the withdrawal resistance of wood screws be renewed?
41. What is understood by the term *intercasting of linked members?*
42. How is freeness obtained between closely joined linked members?
43. Describe the mold arrangement for the swiveled-hook castings.

PART II

LATHE WORK

THE LATHE

The Lathe.—The lathe is a machine tool in which the work, while revolving on a horizontal axis, is acted upon by cutting tools, either manipulated by hand or secured in and controlled by the carriage of the lathe. Wood-turning lathes as shown in Fig. 212 are classified as to their size by the maximum diameter in inches of the work that may be revolved over the ways.

The lathe as shown may be said to comprise five essential units, which are the bed, the headstock, the tailstock, the

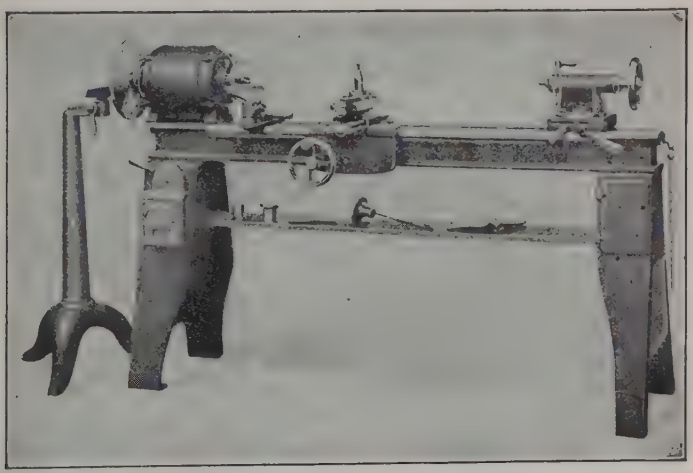


Fig. 212.—Type of lathe used in pattern shops.

carriage, and the tool rest mechanism. When the diameter of the work becomes too large to be turned over the ways, it is mounted upon the outer end of the lathe spindle and a floor stand tool support as shown is used.

To operate any machine tool intelligently and safely, the beginner should be thoroughly familiar with its possibilities, operation, and control. He should study its construction and mechanism and familiarize himself with the names of its component parts. He should also know how to service a machine properly so that it may be maintained in the best running condition.

Wood Turning.—Commonly termed *pattern turning*, and practiced in patternmaking, wood turning differs from what might be termed *ornamental* or *spindle turning* in that the turning chisel takes the place of the gouge and the double-bevel chisel as employed in the latter. The waste is therefore removed by a scraping operation instead of a cutting action. For this reason, the gouge is principally used for roughing down the material preparatory to scraping and the double-bevel chisel used as a cutting-off tool. The purpose in using the scraping method in pattern work is that a high degree of accuracy is more easily obtained by this method.

Lathe-turning procedures are divided into two classifications, namely, between center turning and face-plate work. Between center turning applies to that procedure which permits the waste material being removed while the work is revolving between the centers of the lathe. Face-plate work applies to that procedure in which the size and nature of the work require that the material be turned while secured to a face plate. The face plate is attached to the spindle of the lathe.

The method in which a piece of material is mounted in the lathe for turning will usually depend upon its proportions. If the length is *greater* than the diameter, it is usually turned between the lathe centers. If the length is *less* than the diameter, it is secured to a face plate. However, convenience is often the determining factor in turning small forms.

Because of the wide difference in the diameters of work that may be turned in a lathe, it is necessary to have the lathe spindle revolve at various speeds. Lathes of the type shown may have a variable speed from 600 to 3,000 revolutions per minute.

Objects not exceeding 6 inches in diameter may be safely turned at the maximum speed, but from this diameter upward, the speed is to be *decreased* as the diameter is increased.

Excessive speed in the case of large work becomes a potential hazard.

LATHE JOB 5

Features presented:

- Centering rectangular stock
- Mounting material between the centers of lathe
- Setting the tool rest
- The turning gouge
- Grinding and whetting turning tools
- Outside calipers
- Establishing the diameter of a cylinder
- The parting tool
- The turning chisel
- Application of the dividers
- The double-bevel chisel

Figure 213 is the drawing of a cylinder.

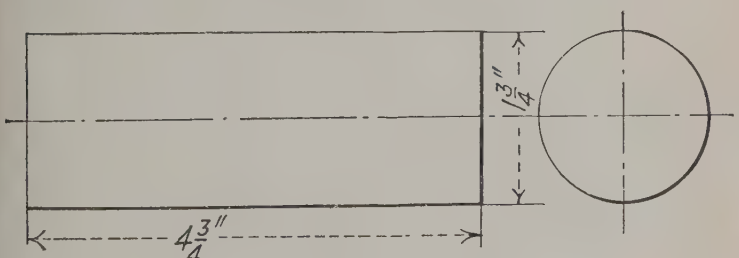


Fig. 213.—Drawing of the cylinder to be turned.

The length of the cylinder is greater than the diameter; therefore it will be turned along the grain of the wood while mounted between the centers of the lathe.

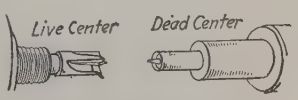


Fig. 214.—The lathe centers.

Figure 214 illustrates and gives the names of the lathe centers.

Stock required: $2 \times 2 \times 6\frac{1}{4}$ inches

ORDER OF OPERATIONS

1. Center the material by drawing diagonals across each end. The center points are located at the intersections of the diagonals.

A hammer should never be used for driving in the live center, for it will probably upset the end of the center and prevent it from properly fitting the spindle. Use a mallet. The dead center, as it is called, because it does not revolve, may be driven in, or it may be forced in by the forward movement of the tail-stock spindle. Exert enough pressure on the center to force it into the wood sufficiently to produce a good impression; then withdraw the center just enough to allow the work to revolve easily. A drop of oil or a little soap, placed in the dead center, will prevent squeaking.

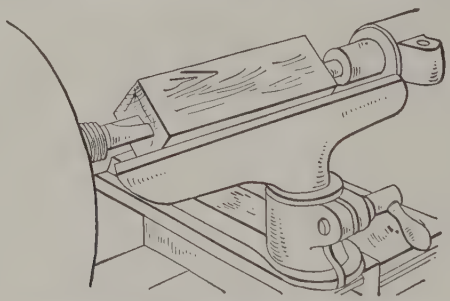


FIG. 215.—A rectangular piece of material mounted between the centers of the lathe.

Figure 215 illustrates the material mounted between the centers of the lathe.

The tool-supporting edge of the tool rest should be set about $\frac{1}{8}$ inch below the axis of rotation and $\frac{3}{8}$ inch in front of the work and parallel to it. As the waste is turned off, the tool rest is moved forward so as to maintain the support of the tool near the work. A disregard for the resetting of the tool rest may result in a broken tool and possible injury.

The Turning Gouge.—The turning gouge is used for roughing down the material preparatory to scraping.

2. With the gouge, rough down the material until a cylinder of the greatest possible diameter has been produced.

Figure 216 illustrates how the gouge is held. The face of the gouge should always be tipped in the direction in which the

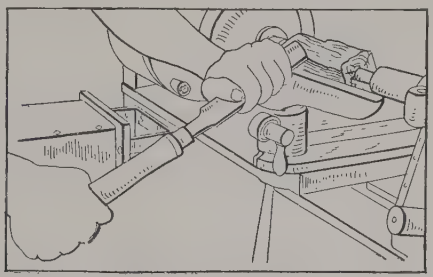


FIG. 216.—Shows how a turning gouge is held when roughing down the rectangular material to cylindrical form.

gouge is being moved; otherwise it is likely to catch and be drawn into the work.

Hold the gouge firmly down on the tool rest. Begin with a light cut at the live-center end. Move the gouge along the tool rest until a cut has been taken throughout the length of the material. Reverse the position of the gouge, and begin the

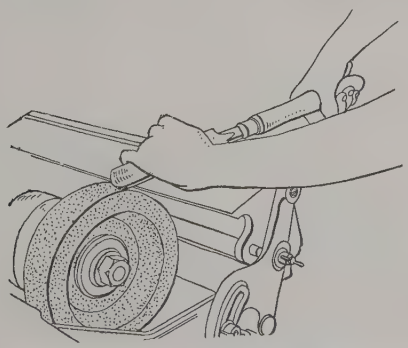


FIG. 217.—A turning gouge being ground upon an abrasive wheel.

cut from the opposite end. Repeat the operation until a rough cylinder of the desired diameter has been turned.

When the repeated whetting of a tool has rounded the cutting edge to the extent that it does not cut easily or smoothly,

the tool should be ground. A turning gouge is shown being ground in Fig. 217.

Don't use a dry stone.

Don't exert enough pressure on a tool when grinding to cause heating of the edge to the extent of drawing the temper.

Don't hold a tool in one place, for a groove in the stone will probably result.

The gouge is whetted as shown in Fig. 218. As the slip stone is given an elliptical movement, the gouge is rocked, so that the entire length of the edge may be sharpened. The

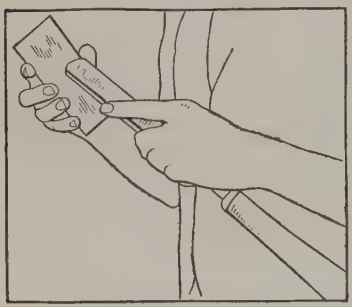


FIG. 218.—A turning gouge being whetted with a slip stone.

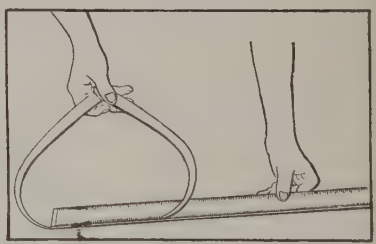


FIG. 219.—How a dimension is taken from a rule with calipers of the firm-joint type.

rounded edge of the slip stone is then applied to the concave surface. It is given a lengthwise movement. Repeat the foregoing operations until a sharp edge has been produced.

Calipers.—Calipers are used by the patternmaker for measuring and transferring the distances between two surfaces and to verify the diameter of turned work.

Figure 219 shows how a dimension is taken from a rule with outside calipers of the firm-joint type. This type of calipers has no means of close adjustment. They are first set to the approximate distance; then the final adjustment is made by tapping the leg lightly in the direction required.

Calipers should be held exactly at right angles to the work and lightly grasped that they may be guided by a sensitive touch.

Calipering revolving work should be carefully done, for injury is likely to result should the calipers catch in the material. For this reason the contact points should be in the form of an arc. If forced against the work, one contact of the calipers will probably be drawn over by the friction of the revolving surface, causing the measurement taken to be

FIG. 220.—The parting tool.

inaccurate and misleading. Always stop the lathe when taking the final measurement of the work.

The Parting Tool.—The parting tool shown in Fig. 220 is used chiefly in establishing diameters or for turning narrow recesses and grooves.

3. Establish with the parting tool and the aid of the calipers, as shown in Fig. 221, the diameter of the cylinder. This operation consists of turning a series of narrow grooves about 1 inch apart throughout the length of the stock. At the beginning of the cut, the handle of the parting tool should

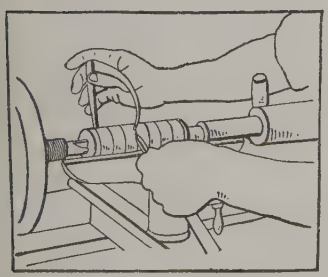


FIG. 221.—How the parting tool and the calipers are held when establishing the diameter of the cylinder.

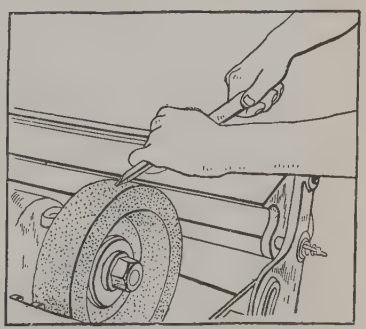


FIG. 222.—How the parting tool is ground upon an abrasive wheel.

point well downward. The lower angle of the cutting edge of the parting tool is kept approximately tangent to the surface being turned. To maintain this position as the work is

reduced in diameter, the handle end of the tool is raised, causing the cutting edge to follow the diminishing surface.

The parting tool is shown being ground in Fig. 222; it is whetted upon both ground surfaces. The included angle of the cutting edge should be about 25 degrees.

The Turning Chisel.—The turning chisel is used for turning flat or convex surfaces.

4. Turn off the waste between the grooves, and complete the cylindrical surface with a turning chisel, as shown in Fig. 223. The chisel should lie flat, in a horizontal position upon the tool rest; the face of the chisel should be upward.

The turning chisel is ground and whetted in the same manner as a plane bit or a paring chisel.

5. Lay off the length of the cylinder.

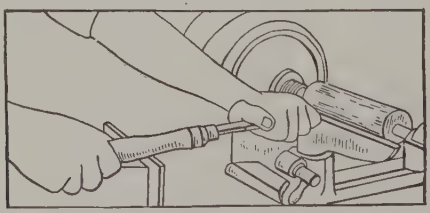


Fig. 223.—How the turning chisel is held while completing the surface of the cylinder.

Figure 224 shows how the dividers are used to transfer the length dimension from the rule to the work. Set the tool rest close up to the work. Hold both points of the dividers down upon the tool rest; then lightly push them against the revolving surface. Failure to place the tool rest close to the work may result in possible injury.

Divide the amount of waste in the length of work between each end, so that the depression made by either center shall not appear in the finished cylinder.

The Double-bevel Chisel.—The double-bevel chisel, as shown in Fig. 225, is used for cutting work to length.

The angle of the cutting edge is ground from each face of the blade as shown, the cutting edge (cutting point) forming an angle of about 60 degrees with one of the long-edge surfaces of the blade.

The tool is held edgewise, upon the tool rest, the cutting being done with the acute-angle point of the blade.

The ground surface of the double-bevel chisel that is toward the work is to lie perpendicular to the axis of the cylinder.

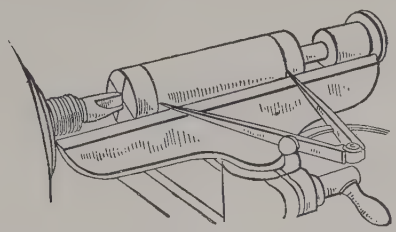


FIG. 224.—How the dividers are used to transfer the length dimension from the rule to the cylinder.

Set the tool rest close to the work, and begin the cut with the handle of the double-bevel chisel pointing well downward. For the beginner, this will be found the most difficult tool to use.

FIG. 225.—The double-bevel chisel.

6. Turn or cut the cylinder to length with the double-bevel chisel as shown in Fig. 226.

If the cutting edge of the double-bevel chisel is tipped toward the work, it will probably catch and be carried over onto the cylindrical surface.

Turn the end surfaces of the cylinder at right angles to its axis. As the turning progresses, the accuracy of the surface

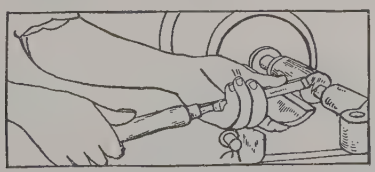


FIG. 226.—The end of the cylinder being turned with the double-bevel chisel.

should be tested with one of the corner edges of the tool. As in the use of the parting tool, the handle of the double-bevel chisel is raised as the cut is carried toward the axis of the cylinder.

Deep cuts will cause excessive friction, which is likely to impair the temper of the tool.

The first cut is made about $\frac{5}{8}$ inch beyond the length of the cylinder. By a series of light cuts, increasing the depth of each succeeding cut, the waste is removed until the end surface of the cylinder is turned. Do not turn the end surfaces farther toward the axial line than about $\frac{5}{16}$-inch diameter. The end of the cylinder toward the dead center should be turned first; the turning of the live-center end completes the lathe work. Should the end of the cylinder toward the live-center be turned first, the small neck that must then drive the work is likely to be broken off when the dead-center end is turned.

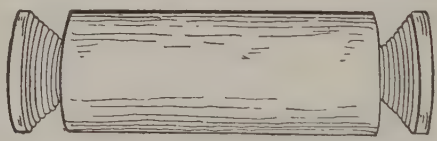


FIG. 227.—The cylinder at the completion of the turning operation.

The work is to appear at the completion of the turning operation, as shown in Fig. 227.

7. Saw off the waste material with a backsaw. Do not deface the appearance of the cylinder by clamping it in the vise while performing this work.

If for any reason a job is to be removed from the lathe before completion, the relative position of the live center to the job should be tally marked in order that the work may be returned to the same position.

Reminders

Check yourself up on safety practices. Get the *safety-first habit.*

When *safety first* causes a delay, it is well worth it and time well spent.

Form the habit of never standing in line with swiftly revolving parts, such as saws, emery wheels, and work secured to face plates.

A ring may be ornamental but a *dangerous* thing to wear when operating any machine tool.

Never *hit* the edge of a tempered tool or hit a file with a hammer; good *eyesight* is a wonderful blessing.

LATHE JOB 6

Features presented:

Taper turning
Mounting work for taper turning
Centering cylindrical stock
Testing a conical surface
Sandpapering a revolving surface
Application of hand screws

Figure 228 is the drawing of a tapered sandpapering roll, as used in sandpapering the wall of the hole in the washer pattern (see Fig. 54, page 52). The saw cut made along the axis of the roll is for the purpose of securing the sandpaper.

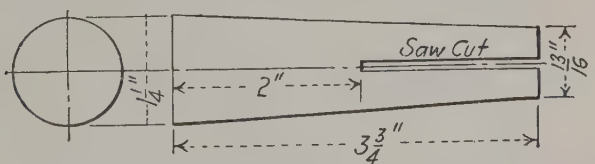


Fig. 228.—Drawing of the sandpapering roll to be turned.

It is a little more difficult to turn an object of a tapered form than to turn one of cylindrical shape.

The usual procedure in turning a tapered object of this kind is to establish at the required distance apart the two end diameters. The waste material is then turned off until a conical surface has been produced.

If desired, the roll may be turned from the preceding job, in which case the center of the stock is found with the dividers or a center square.

Cylindrical stock is centered with the aid of the dividers by scribing arcs (Fig. 229) from three different points upon the circumference. The lathe centers locate at the intersection of the arcs.

Center Square.—A *center square* is a blade so arranged with a square as to have one edge of the blade divide the angle of the square equally. To center cylindrical stock (Fig. 230),

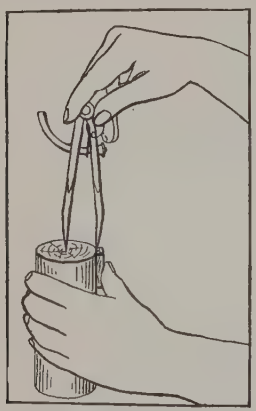


Fig. 229.—Locating the center of cylindrical stock with the dividers.

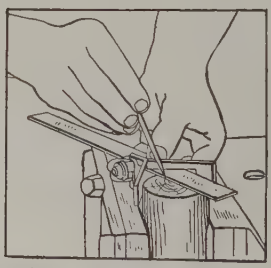


Fig. 230.—Using the center square to locate the center of cylindrical stock.

hold both limbs of the head firmly against the work, and with a scriber draw lines at about right angles.

Stock required: $1\frac{1}{2} \times 1\frac{1}{2} \times 5$ inches

ORDER OF OPERATIONS

1. Center and mount stock as for a cylinder.

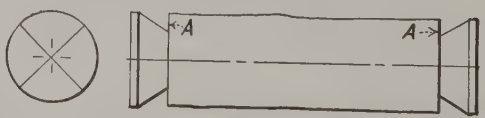


Fig. 231.—The work in the course of turning. The length dimension of the roll has been established.

2. As the length of the roll is given parallel to its axis, turn a rough cylinder of about $1\frac{3}{8}$-inch diameter, and lay off the length of the roll upon it. Use the dividers.

3. Establish the length by partly turning (about $\frac{1}{4}$ inch toward its axis) the end surfaces as at *A* (Fig. 231).

4. Establish the large diameter of the roll by turning a cylindrical surface as at *B* (Fig. 232), whose diameter is equal to this dimension.

5. Establish the small diameter of the roll by turning a cylindrical surface as at *C* (Fig. 232). The diameter *C* is turned in the waste material beyond the limit of the tapered surface.

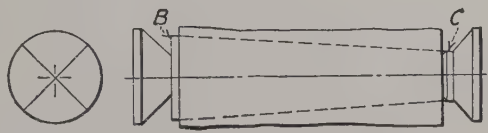


FIG. 232.—The work in the course of turning. The taper of the roll has been established and is indicated in broken lines.

Whenever possible, it is a good practice to arrange the material for tapered work so that the small end of the object shall be toward the dead center. This position not only will tend to eliminate vibration but will permit the small end to be turned more closely to the axial line.

6. Turn the roll to the required taper, as shown in broken lines. As the turning of the conical surface progresses, its accuracy is tested with a straightedge. Do not test the surface while the lathe is in motion. If the edge of the straightedge is blackened with lead, the lead will be transferred to the high places, indicating where further turning is required.

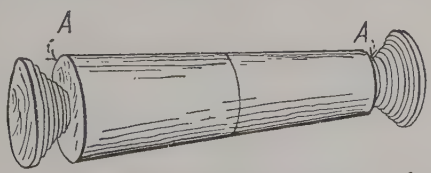


FIG. 233.—The work at the completion of its turning and sandpapering.

7. Turn the end surfaces *A* (Fig. 233) farther toward the axial line (about ¼-inch diameter). Always turn the end that is toward the dead center first; then complete the lathe work by turning the live-center end. If this order of turning the end surfaces is reversed, the small neck that must drive the work may be broken off in turning the dead-center end.

An object may be accurately turned to size, but this feature may be easily destroyed in sandpapering its surfaces. The lathe should be run at a moderate speed, a medium-fine grade of paper used (No. 0) which should be kept in motion over the greatest area possible.

A strip of sandpaper about 1 inch wide and 3 inches long is used in this case. Grip the ends of the strip between the thumb and the first finger of each hand. As the sandpaper is pressed against the surface of the roll and made to conform to it, pass the paper back and forth in the direction of the length of the roll.

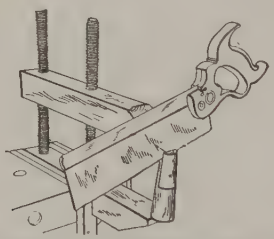


FIG. 234.—Shows how the roll is held in a hand screw while slitting it with a backsaw.

8. Scribe a line around the roll to establish the length of the saw cut. The line along which the saw cut is made is drawn by placing the tool rest against the roll and scribing a pencil line along the top of the rest. Figure 233 illustrates the roll as it will appear when ready to be removed from the lathe.

9. Remove the work from the lathe, and complete the end surfaces as in the case of the cylinder.

Any attempt to clamp a tapered piece of work between the parallel jaws of a vise will result in the defacement of the object.

10. Secure the roll in a hand screw, as shown in Fig. 234, and make the saw cut with a backsaw. The hand screw is held in the vise. (See description and adjustment of hand screws, page 93.)

LATHE JOB 7

Features presented:

Turning core prints

Turning a number of similar-shaped objects from one piece of material

Figure 235 is the drawing of a cope and drag core print.

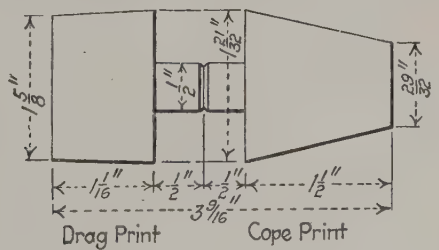


FIG. 235.—Drawing of the core prints to be turned.

When a number of core prints or similar objects are wanted, several may be turned from the same piece of material. This method results not only in the saving of time but in eliminating the waste that would be cut from each end of the objects if turned separately.

Stock required: $2 \times 2 \times 5$ inches

ORDER OF OPERATIONS

1. Mount the material.

2. Turn a cylinder whose diameter equals the greatest diameter of the core prints.

3. Lay off the over-all lengths of the prints.

4. From the line nearest the dead-center end of the work, lay off the length of the tapered or cope print. Lay off from the line nearest the live-center end the length of the drag print.

5. Establish these dimensions by partly turning (about ¼ inch toward its axis) the end surfaces of the prints as at *A* (Fig. 236).

Again attention is called to how the small diameter, as at *B*, is turned in the waste material.

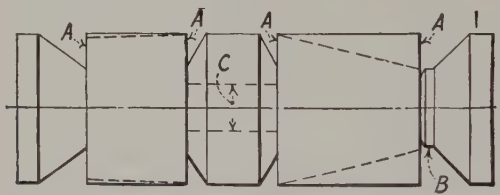


FIG. 236.—Shows how the lengths of the core prints are established by partially turning their end surfaces.

6. Turn the core prints to required shape as indicated by the broken lines.

7. Turn the dowel *C*, and complete the adjacent end surfaces of the prints.

8. Turn the end surfaces farther toward the axial line to about ¼-inch diameter. The work at the completion of the turning operation will appear as shown in Fig. 237.

9. Sandpaper and shellac the work. Do not sandpaper or shellac the dowel or the adjacent end surfaces of the prints.

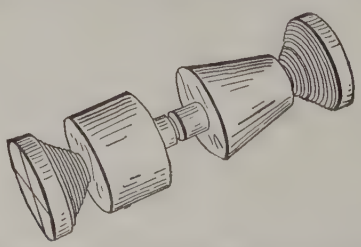


FIG. 237.—The core prints at the completion of the turning operation.

Refer to instruction on shellacking given with pattern 1 (page 47).

10. When the shellac has thoroughly dried (allow at least 30 minutes), remount the work in the lathe, and sandpaper the shellacked surfaces. Use a *very* fine grade of paper.

11. Saw off the waste, and complete the end surfaces with a paring chisel. Sandpaper and shellac the ends.

FACE-PLATE TURNING

Material is usually mounted in the lathe for face-plate turning by one of three methods.

The Screw Plate.—The screw plate *A* or *B* (Fig. 238) is used when the work is comparatively small. The length of the screw *C* is determined by the diameter and the thickness of the object to be turned. No. 14, 16, or 18 is the screw generally used for a screw plate. The hub of screw plate *A* is threaded

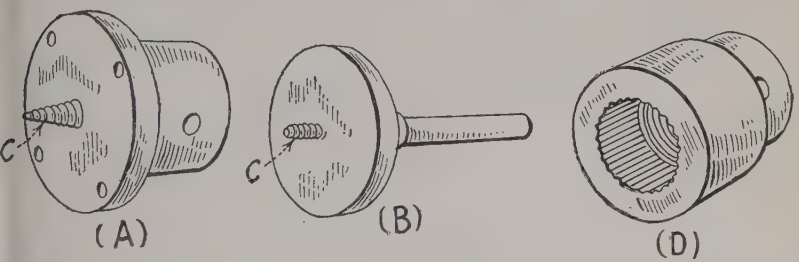


FIG. 238.—Two types of screw plates used in turning small hubs and bosses. The cup chuck *D* is used for turning small forms that cannot easily be turned otherwise.

to fit the ends of the headstock spindle, whereas the one shown at *B* has a tapered shank that enters the spindle.

The Cup Chuck.—The cup chuck *D* is used when the grain of wood lies parallel to the axis of rotation and when it is desired to have the end free in order that this surface may be recessed or turned to the axial line. The material is secured by driving it into the chuck.

Face Plates.—Face plates of the general type shown in Fig. 239 are used when the material exceeds 6 inches in diameter or when the center screw *C* (Fig. 238) would interfere with the turning operation at or near the center of rotation.

Face plates vary in diameter from 3 inches up. Their selection depends upon the size and nature of the work. The screws securing the material to a face plate should be placed at

as great a distance from the center of rotation as the work will permit.

The material is secured by two or more screws as the case may require. They are inserted through holes in the flange of the face plate.

Because of the wear occurring between the thread in the face plate and the thread on the spindle, the face plate will not always run true when mounted.

Whenever a true running surface is required for the mounting of work, an intermediate wood facing is to separate the

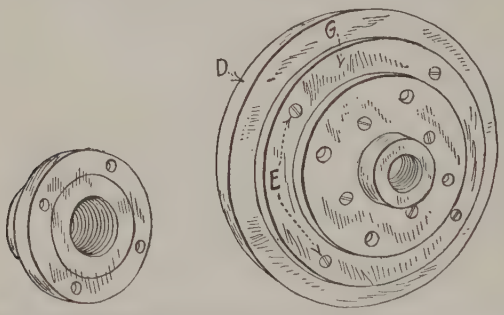


FIG. 239.—The type of face plates in general use for patternwork.

work from the face plate as shown at *G*, Fig. 239. The facing material should be secured to the face plate and then carefully trued up to receive the pattern material *D*.

If the diameter of the material *D* will not permit the locating of the screws *E* outside the limit of the face plate, as shown, the screws securing the facing *G* are withdrawn and screws inserted that are long enough to pass through the facing and enter the work. To prevent the displacement of the facing *G*, each screw, as it is withdrawn, is replaced by a longer screw before withdrawing another screw.

Screw holes left by the screws used to secure work to a face plate are not to be relied upon to bring the work back to its original setting.

Unfinished work should never be removed from a face plate unless provision has been made for its correct replacement.

QUESTIONS

1. What is understood by the expression *between center turning?*

2. What is understood by the expression *face-plate turning?*

3. What usually determines the way a piece of work is to be mounted in the lathe?

4. What is meant by dead center?

5. What is meant by live center?

6. How is rectangular stock usually centered?

7. Why should a hammer never be used to drive the live center into the material?

8. What makes the dead center become heated, causing it to squeak?

9. How may the squeaking be stopped?

10. How should the tool rest be set in its relation to the work to be turned?

11. Why should the rest be kept near the surface being turned?

12. For what purpose is the turning gouge principally used?

13. Why should the face of the gouge be tipped in the direction the cut is being made?

14. For what purpose are calipers used?

15. How is the final adjustment made with calipers of the firm-joint type?

16. Why should calipering revolving work be carefully done?

17. For what purpose is the parting tool principally used?

18. What position should the lower angle of the cutting edge of the parting tool bear to the surface being turned?

19. For what purpose is the double-bevel chisel principally used?

20. What position should the ground surface of the double-bevel chisel that is toward the surface being turned bear to this surface?

21. What portion of a double-bevel chisel does the cutting?

22. Why should the finishing of the end of the work toward the dead center precede the finishing of the live-center end?

23. How is a conical surface tested?

24. Describe the construction of the center square, and explain its use.

25. Why is it good practice to arrange the material so that the small end of a tapered object will be toward the dead center?

26. What is the advantage in turning a number of similar-shaped objects from the same piece of material?

27. How is the taper of a conical-shaped roll established?

PATTERN 32

BASE

Features presented:

- Face-plate turning
- Preparing and mounting material upon a face plate
- Application of the dividers
- The spear-point tool
- The round-point tool

Figure 240 is the drawing of a cast-iron base.

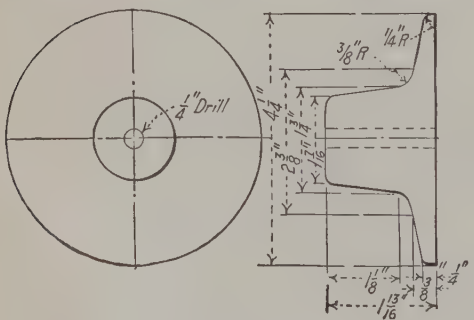


FIG. 240.

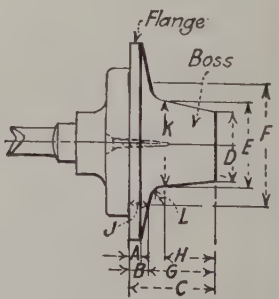


FIG. 241.—Reference diagram, with letters representing the various dimensions.

The casting consists of a circular flange of diminishing thickness supporting a tapered boss.

A fillet connects the conical surfaces of the boss with the conical surface of the back of the flange.

The 1/4-inch hole through the center of the casting is specified to be drilled.

Figure 241 is used for reference; letters designate the various dimensions of the pattern.

The diameter of the base pattern is greater than its length; therefore it will be turned across the grain of the wood while it is secured to a screw plate.

Material to be mounted upon a screw plate is sawed in the form of a disk. The disk is to be $\frac{1}{4}$ inch greater in diameter than the required pattern and $\frac{1}{8}$ inch greater in thickness.

The surface of the material that is placed against the screw plate is to be planed true.

For the patterns to follow, the foregoing operations will be referred to as prepare the material for mounting.

Stock required: $1\frac{15}{16} \times 4\frac{3}{4} \times 4\frac{3}{4}$ inches

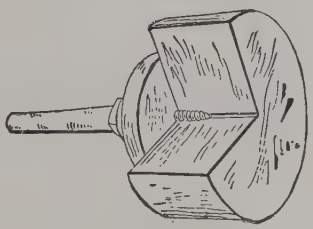


FIG. 242.—The material that has been sawed is shown in the form of a disk mounted upon a screw plate.

ORDER OF OPERATIONS

Figure 242 shows the material mounted upon a screw plate. Sufficient accuracy will be obtained by mounting the work as shown. One quarter of the material has been removed in order to expose the screw. The screw used in this case is No. 14. It enters the wood about 1 inch.

1. Mount the material upon a screw plate, and reduce to the greatest given diameter of the pattern.

The roughing-down operation is to be done with a turning chisel. Do not make a cut with the full width of the chisel, but remove the waste by making cuts of $\frac{1}{8}$-inch width. Any attempt to take a heavy cut with the full width of the chisel or with a dull chisel will probably result in stripping the material from the screw. Turning across the grain of wood destroys the cutting edge of a tool very quickly and necessitates frequent whetting.

2. Upon the circumference turned, scribe with the dividers the dimensions of the patterns represented by the letters *A*, *B*, and *C* (Fig. 241).

3. Reduce the material to the dimension represented by *C*. To perform this operation, the tool rest is set at right angles

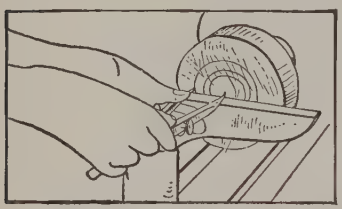


Fig. 243.—Shows how the dividers are held while scribing the various circumferences upon the material.

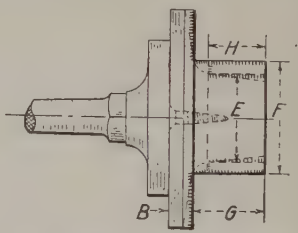


Fig. 244.—The work at the completion of turning the flange to its greatest thickness.

to the axis of rotation of the lathe or in front of the material. Set the tool rest so that the tool will be supported near the surface being turned.

4. Revolve the work, and locate with pencil the center of rotation. From this point scribe with the dividers, as illustrated in Fig. 243, circumferences the diameters of which are represented by *D*, *E*, and *F* (Fig. 241).

Fig. 245.—The spear-point tool.

5. Establish the thickness of flange at *J* (Fig. 241) by turning, as shown in Fig. 244, a cylinder whose diameter is represented by *F* and length by *G*.

6. Turn the flange to its diminishing thickness, as shown in broken lines. The spear-point tool or the turning chisel may be used for this operation.

The Spear Point.—The spear-point tool, as shown in Fig. 245, has two cutting edges inclined to one another and meeting at an acute angle. It is used for turning surfaces that are not

accessible to or cannot be conveniently turned with a turning chisel. It is whetted in the same manner as the turning chisel.

7. Establish the large diameter of the boss as at *K* (Fig. 241) by turning, as shown in Fig. 244, a cylinder whose diameter is represented by *E* and length by *H*.

8. Turn the conical surface (taper) of the boss.

9. Turn the fillet *L* (Fig. 241). The round-point tool is used for this operation.

The Round Point.—The round-point tool, as shown in Fig. 246, has the cutting edge curved. It is used for turning concave surfaces.

The whetting of a round-point tool should be performed by rocking it as it is pushed forward over the surface of the stone. The tool is held while being ground in the same manner as the turning gouge (Fig. 217). The curve of the cutting edge depends somewhat upon the width of the blade.

FIG. 246.—The round-point tool.

10. Turn the rounded corner of the flange. Rounded corners are to be turned with the turning chisel or spear-point tool.

If the drawing shows a rounded corner and it is not dimensioned, assume that a $\frac{1}{16}$-inch radius is required.

11. Sandpaper, then shellac the pattern. When the shellac has thoroughly dried, sandpaper the work in the lathe.

12. Detach from the face plate, and close with a wooden plug or wax the hole in the face of the flange made by the screw; then sandpaper and shellac this surface of the pattern.

Work should never be removed from a screw plate until the turning operation has been completed.

PATTERN 33

COLLAR

Features presented:

√ Locating material upon a face plate
√ Securing material to a face plate
√ Turning an interior surface or wall of a hole
Inside calipers
Sandpapering revolving interior surfaces

Figure 247 is the drawing of a cast-iron collar.

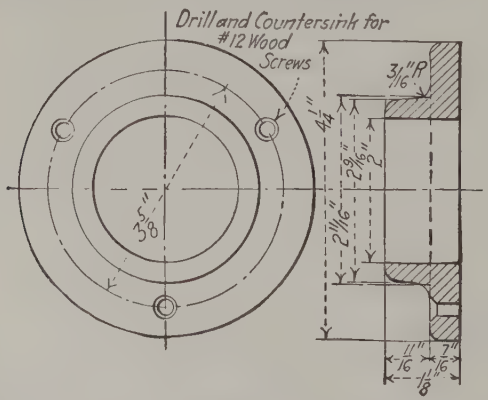


FIG. 247.

The casting consists of a circular flange from which projects a ring.

Three holes appear in the flange. The drawing specifies that they are to be drilled and countersunk for No. 12 wood screws.

Countersinking is the conical enlargement of the end of a hole. This is a machine-shop operation and does not affect the pattern.

It will be readily seen that the material for the pattern cannot be mounted upon a screw plate, since the screw would interfere with the turning out of the hole. It is therefore mounted upon a face plate.

The work may be directly attached to the face plate with two screws, as shown at *A* (Fig. 248) or it may be separated from it, as shown in Fig. 249, by a piece of facing material indicated by *B*. Whenever a close degree of accuracy is desired, this method should be used, for it assures a true running surface upon which to mount the work. Another advantage is that it allows the wall of the hole to be turned to completion without the edge of the turning tool coming in contact with the metal face plate.

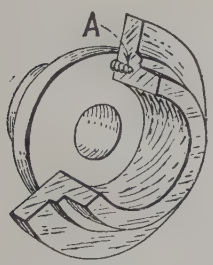


FIG. 248.—Shows the material from which the collar pattern is being turned directly attached to the face plate.

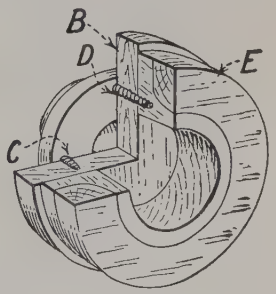


FIG. 249.—The material for the collar pattern separated from the face plate by the facing *B*.

The face plate contains four screw holes. The facing *B* is attached by two screws inserted through holes that are diametrically opposite.

The material *E* for the pattern is secured by the screws *D*, which pass through the face plate and the facing *B*.

To locate the face plate upon the material (Fig. 248), scribe a circumference that is the diameter of the face plate.

Figure 250 is used for reference in dimensioning the pattern.

Stock required: $1\frac{1}{4} \times 4\frac{5}{8} \times 4\frac{5}{8}$ inches

ORDER OF OPERATIONS

1. Prepare and mount the material upon a face plate. Be careful that the portion of the screws, entering the material, does not exceed the thickness of the flange, and, as a result, interfere with the turning of this member. Avoid placing screws in the same line of fiber of short grain wood, since doing so is likely to cause it to split apart.

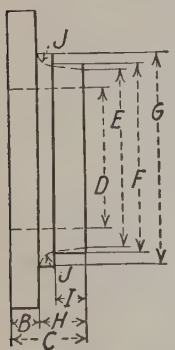


FIG. 250.—The reference diagram used in dimensioning the collar pattern.

2. Turn the material to the greatest diameter of pattern; then upon its circumference scribe the dimensions represented by *B* and *C* (Fig. 250).

3. Turn the thickness of the material down to dimension *C*.

4. Upon the face of the material, scribe the circumferences represented by *D*, *E*, *F*, and *G*. Diameter *G* is the large diameter of the ring portion plus twice the radius *J*.

Since a form will be less likely to split during the turning if the inside is turned before the outside, this will be the procedure.

The spear-point tool (Fig. 245) or the right skew shown in Fig. 254 may be used for turning the interior surface. Failure to keep the tool sharp, or firmly held down upon the tool rest in a horizontal position, will result in an inaccurate surface.

5. At the center of rotation, begin operations with the point of the tool, taking light cuts and working toward the circumference until a hole slightly less than the given diameter *D* has been turned through the material. With the aid of the inside calipers, turn the hole to the required diameter.

Refer to draft allowance and its application to the wall of a hole, pattern 2 (page 50).

Inside Calipers.—Inside calipers are chiefly used for transferring dimensions to interior surfaces.

Warning: Never attempt to use the inside calipers while the lathe is in motion.

Figure 251 shows the correct way of taking a dimension from the rule with the inside calipers of the spring type. The rule should lie perpendicular to the surface against which it is held.

6. Turn the flange to thickness B; then draft the edge surface. The thickness of the flange is formed by turning a cylinder whose diameter is represented by G and length by H.

7. Turn a cylinder whose diameter is represented by F and length by I (Fig. 250).

8. Turn the ring to required shape. (Taper.)

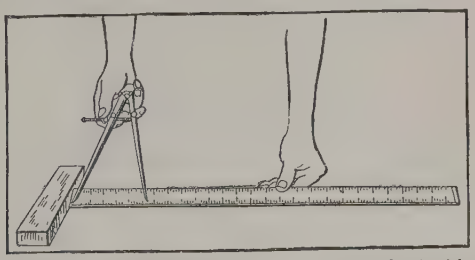


FIG. 251.—Taking a dimension from a rule with the inside calipers.

9. Turn the fillet J, and round the corner of the flange and the ring [see information pertaining to the rounding of corners (page 215)].

To sandpaper the interior surface of the pattern, fold a piece of sandpaper to about ½-inch width, and hold it under the first or second finger.

Finish the pattern as instructed on page 215.

Screw holes left by the screws used to secure work to a face plate are not to be relied upon to bring the work back to its original setting. If its removal is found necessary, its position should be registered by attaching to the material three small blocks at equal distances about the circumference of the face plate.

PATTERN 34

COVER

Features presented:

- Rechucking a piece of work
- Determining the surface to be turned first
- Separating a piece of work from a face plate with a turning tool
- Right- and left-hand skew chisels
- Securing a piece of work to a false chuck by friction
- Chalking contacting surfaces to obtain additional adherence
- Application of the dividers

Figure 252 is the drawing of a brass cover.

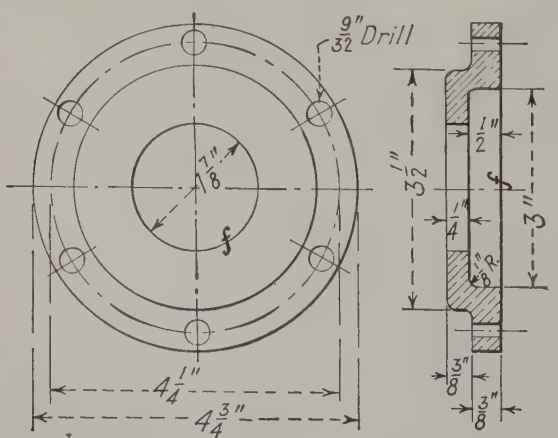


Fig. 252.

The casting consists of a circular flange supporting a web of ¼-inch thickness. A 1⅞-inch-diameter finished hole is required in the web (see Finish Allowance for Brass, page 54).

Whenever a green-sand core forming a hole in a casting is delivered by the pattern and the hole is required to be finished, the finish allowance is to be increased by the amount of draft given the walls of the hole.

The face of the flange is required to be finished; therefore it will be molded in the drag. Surfaces are to be drafted accordingly.

Note: Consider carefully how finish allowance provided upon the face of the flange will affect the proportioning of the depth of the recess, the thickness of the flange, and over-all thickness of the pattern.

Rechucking.—When all surfaces of a pattern are to be turned to dimension, an operation known as *rechucking* is involved. This means that at the completion of the turning of one face of the pattern, the work is detached from the face plate and reversed. This allows the surface that was against the face plate to be turned. The face of the work to be turned first will usually depend upon the shape of the pattern.

Stock required: $15/16 \times 5\frac{1}{8} \times 5\frac{1}{8}$ inches Pattern
$7/8 \times 4\frac{1}{8} \times 4\frac{1}{8}$ inches Chuck

ORDER OF OPERATIONS

1. Prepare and mount the material upon a screw plate.

2. True up the face of the material; then turn to the greatest diameter of the pattern.

The recessed face of the pattern will be turned first, because the circular wall of the recess affords the best means of centering and securing the work to the chuck. Attention is called to this feature, because the general practice is to turn first that face of an object which affords the most accurate and secure way of rechucking.

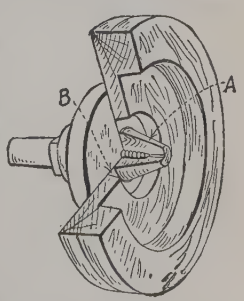


FIG. 253.—The work at the completion of the turning out of the recess.

3. Scribe upon the face of the material a circumference whose diameter is that of the recess. Then

proceed to turn out this depression to the shape shown in Fig. 253. The bottom surface of the recess is not carried to the center of rotation, but stock is allowed to remain about the screw at *A*.

4. Sandpaper and apply one coat of shellac to this face of the work.

Fig. 254.—The skew chisel.

The Skew Chisel.—The skew chisel (Fig. 254) is a modified spear-point tool. It is used to turn the walls of small holes or openings that are not accessible to the wider blade of the spear-point tool. The included angle of the point should be about 20 degrees. Skew chisels are usually made in pairs, right-hand and left-hand.

5. Separate the work from the face plate with a skew chisel by turning a groove of $1\frac{5}{8}$-inch or less diameter to within $\frac{1}{16}$ inch of the face plate, as at *B* (Fig. 253). The work is then removed from the plate and the separation completed with the point of a knife.

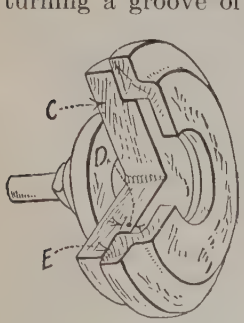


Fig. 255.—Shows the work rechucked and the turning operation completed.

The chucking material or false chuck, as indicated by *C* (Fig. 255) is sawed about $3\frac{7}{8}$ inches in diameter (thickness unimportant) and attached to a screw plate.

6. Prepare and mount the chucking material; then turn upon its face the projection indicated by *D*. Make projection *D* about $\frac{1}{4}$ inch. This projection is to enter the recess as shown.

Since the work is secured to the chuck by friction, it is very important that a close fit be made between the circumference of the projection *D* and the wall of the recess. To obtain a true setting, the surfaces of the chuck and of the work must come in contact, as at *E*.

Usually a slight inaccuracy will be found in the diameter of a cylindrical surface turned across the grain of the wood. This is due to the variation in the distribution of the harder end grain wood. To compensate for this difference in the contacting surfaces, the work should be placed upon the chuck so that the grain of the wood in the work and in the chuck will lie in an opposite direction.

Additional adherence may be obtained by chalking the circumference of the projection *D*.

7. Scribe upon the circumference of the material the thickness of the flange and the overall thickness of the pattern. Then turn the material to the latter dimension.

Whenever laying out or scribing the circumference of a hole the wall of which is required to be finished, keep in mind that the finish allowance is to be subtracted from the radius of the hole.

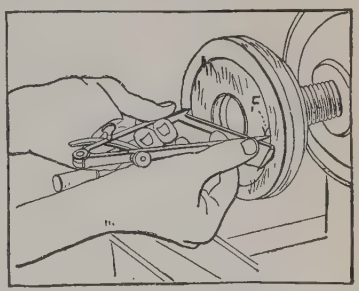


FIG. 256.—Shows how a circle may be scribed upon a revolving surface with the dividers, where the center of rotation has been destroyed.

8. Scribe upon the face of the material circumferences that represent the diameter of the hole and the diameter of the web.

Figure 256 illustrates how a circumference may be scribed with a pair of dividers upon a revolving surface when the center of rotation of the surface has been destroyed or is inaccessible. The dividers are set to the required diameter of the circle. Point *F* of the dividers does not touch the surface of the work but is used to locate the scribing point and to verify the dimension. The tool rest is set close to the surface.

Note: Should the drawing show a rounded corner and it is not dimensioned, assume that a $\frac{1}{16}$-inch radius is required. If a fillet is not dimensioned, assume, on small machine parts, that a $\frac{1}{8}$-inch radius is required.

9. Complete the turning operation, and finish the pattern in the usual way.

PATTERN 35

CYLINDER HEAD

Features presented:

Application of templets

Laying out templets

Figure 257 is the drawing of a cast-iron cylinder head.

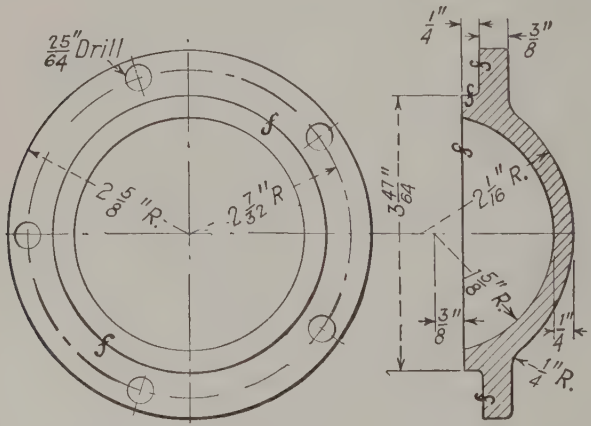


Fig. 257.

The casting consists of a circular flange supporting a spherical shell. Extending out from the face of the flange is a $3\frac{47}{64}$-inch cylindrical projection. As indicated by finish marks, machine finish is required upon the face surface of the flange and upon the diameter and end surface of the cylindrical projection. Often the beginner does not see the effect that the addition of finish allowance to adjacent surfaces (as in the present case) will have upon the proportions of the pattern to those of the finished casting. Whenever in doubt, make a rough sketch of the finished casting. If lines are now drawn

on the sketch indicating the finish allowance added to the surfaces requiring this operation, the effect upon the pattern will be readily seen, as indicated by the letters *A*, (Fig. 260).

Surfaces of circular patterns are very often of such form or cross section that templets are needed to test the correctness of their outline as the material is reduced to shape. In order to turn the spherical surface of the shell portion of the cylinder-head pattern, a reference is required; hence the use of templets.

The two templets are made by laying out a cross section of the pattern, as shown in Fig. 258, in the following way upon a

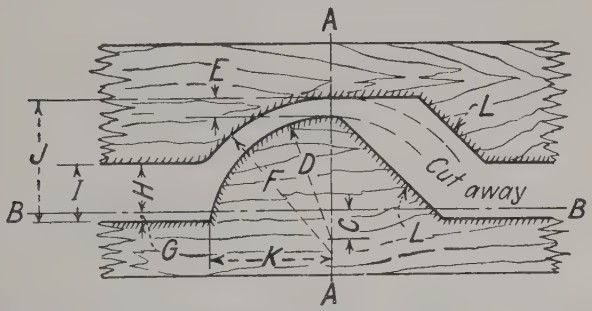


FIG. 258.—Shows how the templet is made by laying out a radial cross section of the head, and when cutting away the enclosed material.

piece of material of about $\frac{3}{16}$-inch thickness. The enclosed material representing the cross section is then cut away.

Scribe line *A*; gage line *B* about 1 inch from the edge of the material; lay off distance *C*; scribe an arc using the radius *D*; lay off the distance *E*; scribe an arc using the radius *F*. Lay off the dimensions represented by *G* and *H*, and scribe lines parallel to line *B*. The dimension represented by *G* is the amount of finish allowance to be provided upon this surface of the casting.

The testing surface of the templets need only represent a radial outline of the surface to be shaped; therefore, the templets are cut away or given clearance as at *L*.

Do not saw the templets to shape until the dimensions represented by *I*, *J*, and radius *K* in turning operation 3 have

been transferred from the layout of the templets to the material.

Stock required:	$1\frac{3}{4} \times 5\frac{5}{8} \times 5\frac{5}{8}$ inches	Pattern
	$1 \times 5\frac{1}{2} \times 5\frac{1}{2}$ inches	Chuck
	$\frac{3}{16} \times 3\frac{1}{2} \times 6\frac{1}{4}$ inches	Templets

ORDER OF OPERATIONS

1. Prepare the material, and mount upon a face plate as shown in Fig. 259.

2. True up the face, and then turn to the greatest diameter of the pattern.

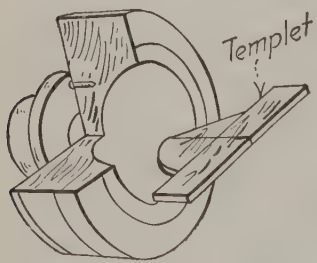


Fig. 259.—The templet in position for testing as the turning of the interior surface of the pattern proceeds.

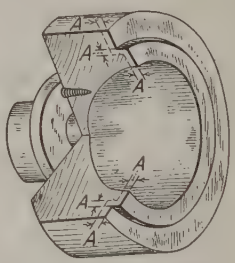


Fig. 260.—The work at the completion of the turning of this face of the pattern.

3. From the face of the work lay off and scribe upon the circumference the dimensions represented by *I* and *J*. Scribe upon the face of the work a circumference using the radius *K*. Transfer these dimensions from the layout of the templets.

4. Scribe upon the face of the work a circumference that is the diameter of the cylindrical projection upon the face of the flange (Fig. 260).

5. Turn out the spherical depression. The round-point tool is used for this operation.

As the turning of this surface nears completion, the lathe should be stopped frequently and the surface tested with the templet. This operation is repeated until the surface exactly corresponds to the outline of the templet and the straightedge of the templet comes in contact with the face of the work.

In making a test, the face of the templet is to lie in the same plane as the center of rotation. The outline of the templet will be impaired if testing is attempted while the work is in motion.

Figure 260 illustrates the work at the completion of this operation.

6. Turn the cylindrical projection on the face of the flange, and finish this face of the pattern in the usual way.

The cylindrical surface of the projection on the face of the flange is the means of centering and attaching the work to the chuck.

Like the preceding pattern, the work is secured to the chuck by friction.

7. Prepare and mount the chucking material, and rechuck the work (Fig. 261). Refer to the information on page 222 pertaining to the contacting surfaces of the work and chuck.

Figure 261 illustrates the pattern at the completion of the turning operation.

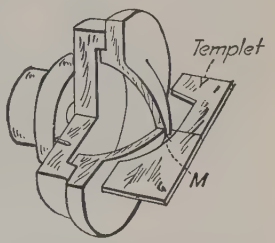


FIG. 261.—The templet in position for testing, as the shaping of the exterior surface of the pattern progresses. The sectional views show how the pattern is secured to the chuck.

8. Reduce the work to the dimension represented by *J* (Fig. 258).

9. Allowing a 1⅞-inch radius of stock to remain about the axis of the work, turn the flange thickness as represented by *I* (Fig. 258) back to this point; then turn the spherical surface.

At the completion of this operation, the straightedge of the templet will be in contact with the back surface of the flange and the center line *A* of the templet, coinciding at *M* (Fig. 261) with the axis of the work.

10. Finish the pattern in the usual way.

PATTERN 36

HANDWHEEL

Features presented:

Scribing a line upon an irregular surface
Application of templets
Securing rechucked work
Application of the dividers

Figure 262 is the drawing of a cast-iron handwheel.

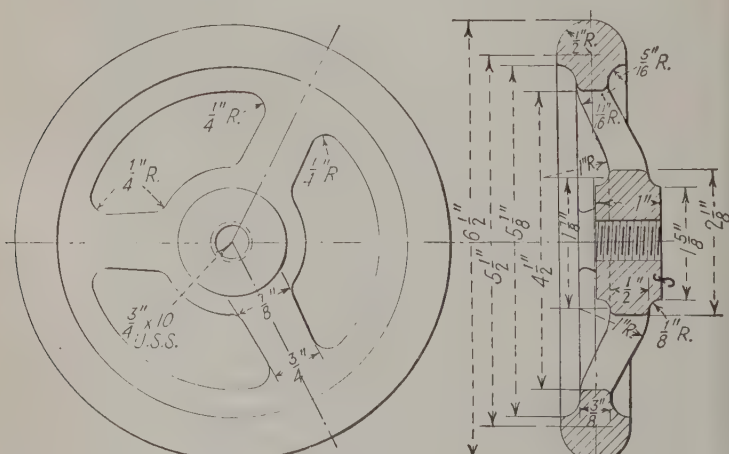


Fig. 262.

Handwheel patterns of small diameter and similar in form to the one shown are usually turned from one piece of wood. The shape of the arms is then laid out upon the web that connects the hub with the rim and later dressed to shape.

The templets required for the turning operation are made by laying out upon a thin piece of material a radial section of

the pattern as shown in Fig. 263. The outline of the pattern is then cut away.

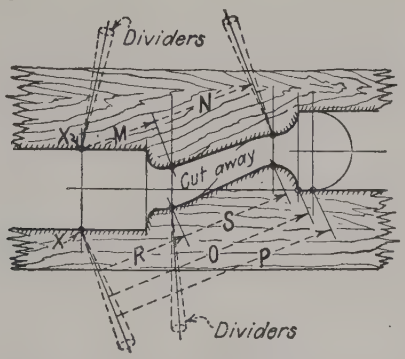


FIG. 263.—The templets used in shaping the pattern. The illustration shows also how the radii for various circumferences are transferred from the templets to the work.

Stock required:	$1\frac{3}{4} \times 6\frac{7}{8} \times 6\frac{7}{8}$ inches	Pattern
	$1 \times 5\frac{7}{8} \times 5\frac{7}{8}$ inches	Chuck
	$\frac{3}{16} \times 3\frac{1}{4} \times 4\frac{3}{4}$ inches	Templets

ORDER OF OPERATIONS

1. Prepare and mount the material upon a face plate.

2. True up the face; then turn to the greatest diameter of the pattern. The depressed face of the pattern will be turned first.

3. Scribe upon the face of the work the circumferences represented by *A* and *B* (Fig. 264).

4. From the face, lay off and scribe upon the circumference of the work the dimensions represented by *E* and *F*.

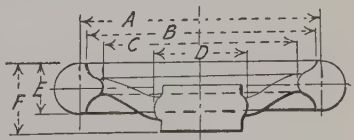


FIG. 264.—Reference diagram.

5. Turn a depression in the face down to the surface of the hub ($\frac{1}{2}$ inch deep) and about $2\frac{1}{2}$ inches in diameter; then scribe upon it a circumference that is the diameter of the hub.

6. Turn this face of the work to conform to its templet; then sandpaper the surface.

7. Scribe the circumferences represented by *C* and *D*. To scribe these circumferences from the center of rotation, the

distances represented by XM and XN are taken from the templets and used as the radii. The reason for these radii being used instead of the given radii is that the center of rotation upon the face of the hub is not in the same plane as the points upon the surface of the web where the circumferences are scribed.

8. Divide the circumference of the work into three equal parts; to secure the maximum strength, scribe the center line of one arm in the direction of the grain of the wood. Square lines across the lateral surfaces as indicated by H (Fig. 265). From these division lines, scribe the center lines of the arms.

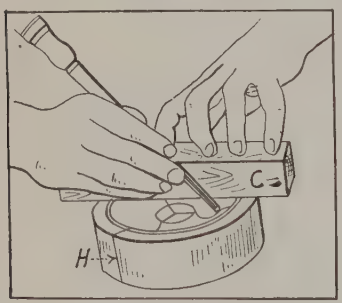


FIG. 265.—Shows how the center lines of the arms may be scribed with the aid of a block and narrow chisel.

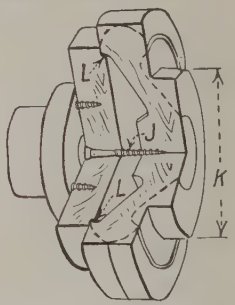


FIG. 266.—Sectional views of the partially turned work attached to the chuck.

Figure 265 illustrates the method employed in scribing the center lines. The surface of block C is placed and held in a true plane with the required location of the line. The line is scribed with a narrow chisel while the face of the blade is held against the surface of the block as shown.

9. Lay out the shape of the arm upon heavy drawing paper; then cut it to shape. This templet is then used to trace the outline of the arms upon the surface of the web.

10. Rechuck the work. The work is centered by the $\frac{1}{16}$-inch projection, turned upon the face of the chuck as at L (Fig. 266). The work is secured to the chuck with a screw located at J. The diameter of the chuck cannot exceed $5\frac{1}{2}$ inches, since it would interfere with the turning of the surface of the rim.

11. Turn the material to the thickness represented by *F* (Fig. 264), then upon the face surface scribe a circumference equal to the diameter of the hub.

12. Reduce the rim thickness to the dimension represented by *E* (Fig. 264) forming a cylindrical projection, as at *K*, of about 3¾ inches in diameter (Fig. 266).

13. Using the distances *XO* and *XP* (Fig. 263) of the templet as radii, scribe circumferences as represented by *A* and *B* (Fig. 264).

14. Proceed with the aid of the templet to turn this face of the pattern to shape; then sandpaper this surface, and scribe the circumferences *C* and *D*, using for the radii *XR* and *XS* of the templet.

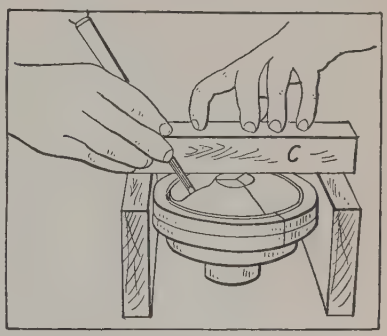


FIG. 267.—Shows how three pieces of wood and a narrow chisel may be used to scribe the center lines of the arms.

15. Transfer to this face the center lines of the arms. Figure 267 illustrates how two blocks are used to support block *C* above the work while the center lines are scribed.

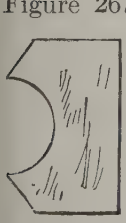


FIG. 268.—Templet used in turning the outer surface of the rim.

16. Trace from the paper templet the outline of the arms upon this surface of the web.

17. Turn the convexed surface of the rim. A templet, as shown in Fig. 268, is used to test the surface.

18. Dress arms to shape. The arms are roughly shaped by removing the enclosed waste material with a compass saw, as illustrated in Fig. 129. To insert the saw blade through the web, bore ½-inch holes at the centers of the ¼-inch fillets connecting the arms with the beading of the rim.

Following the shaping of the plan view of the arms and the beading on the inside of the rim with a gouge, the narrow

blade of a knife is best adapted to rounding the edges of these members.

THE SURFACE PLATE AND ITS USEFUL ADJUNCTS

A surface plate is a cast-iron plate ribbed to give lightness, strength, and staying qualities. It is machined on all outside surfaces and is used as a base upon which to rest the work in dimensioning or checking distances or in scribing lines.

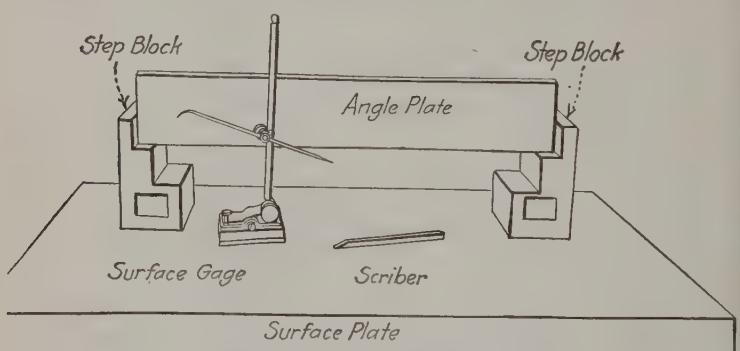


FIG. 269.—The surface plate and its useful adjuncts.

An angle plate is a cast-iron *L*-shaped bar, machined on faces, edges, and ends. It is used chiefly as a guide for the scriber in scribing lines upon irregular or depressed surfaces.

A step block is a cast-iron step-shaped block machined on all outside surfaces used as a guide for the scriber and as a support for the angle plate.

The scriber as used with an angle plate is a piece of tool steel about $\frac{5}{16}$ inch square and 9 inches long, with one end beveled so as to form an angle of about 20 degrees with one face. The scriber shown as a part of the surface gage is a slender piece of tool steel 8 or 10 inches long, sharp pointed at both ends, one end bent to approximately a right angle, the points hardened and tempered.

A surface gage is a tool with a heavy base supporting a scriber that is adjustable to height. It is used chiefly in

transferring vertical dimensions from a flat surface to a point on the work.

QUESTIONS

1. What is understood by face-plate turning?
2. Describe a cup chuck.
3. How is the material prepared for mounting upon a screw plate or face plate?
4. What is understood by the center of rotation?
5. Describe and explain the use of the spear-point and the round-point tool.
6. Describe the procedure in turning to size the hole in the collar pattern.
7. Why should inside calipers never be used while the work is revolving?
8. What is understood by the term *rechucking* as applied to turning?
9. What face of a pattern requiring rechucking is usually turned first?
10. For what purpose is the skew chisel used?
11. When a piece of work is to be secured to a chuck by friction, how may additional adherence be obtained?
12. How may a circle be scribed upon a revolving surface when the center of rotation of the surface has been destroyed or is inaccessible?
13. Explain the reason for using a templet in shaping the cylinder-head pattern.
14. Why is the depressed surface of the cover or the cylinder-head pattern turned first?
15. Describe the method employed in scribing the center lines of the arms of the handwheel pattern.
16. What distance is taken and used as the radius when the center of rotation and the surface upon which the circumference is to be scribed are not in the same plane?
17. What is a surface plate, and for what purpose is it used?
18. What is a surface gage, and for what purpose is it used?
19. What two adjuncts of the surface plate may be used in scribing a line over an irregular surface?
20. What should be the relative position of the grain of the wood in the chuck to that of the work being turned?
21. What dimensions of the cylinder head are changed by the addition of finish allowance to the surfaces of the pattern?

PATTERN 37

STAR WASHER

Features presented:

Construction

Half-lap joint

Turning an interrupted surface

Figure 270 shows the drawing of a cast-iron star washer.

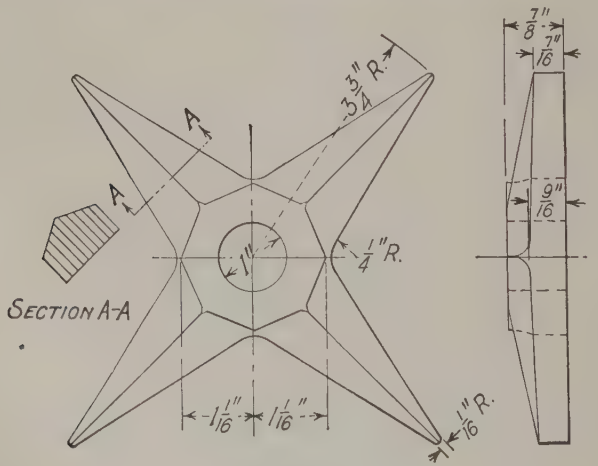


FIG. 270.

If strength and durability were of no importance, the pattern for the star washer could be made from one piece of wood. If this arrangement were followed, however, two of the points of the star would contain short grain wood and could be easily broken.

Wood is strongest in a transverse direction to its grain; therefore, whenever durability is required, the wood should be

so joined together that its grain will lie in such a direction as to give the greatest strength to the pattern.

Two pieces of material half-lapped together, as shown in Fig. 271, will make each point of the star lie in the direction of the grain of the wood and thereby receive its maximum strength.

Stock required: $1 \times 2\frac{3}{4} \times 16$ inches

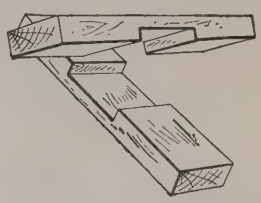


FIG. 271.—The material for the star-washer pattern half-lapped and ready to be glued together.

ORDER OF OPERATIONS

1. Reduce the material to $\frac{15}{16}$ inch in thickness and $2\frac{1}{2}$ inches in width, then separate it at the middle of its length.

2. At the center of the length of each piece, lay out and make a half-lap joint as shown. Refer to the information on the router (page 102). Do not make the joint so tight that the parts must be forced together, for it will probably distort the face of the material.

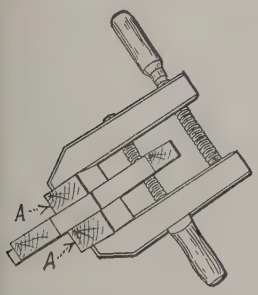


FIG. 272.—Shows how a hand screw with the aid of two blocks clamp the material together while the glue is drying.

3. Glue parts together. Exert the pressure of the hand screws (Fig. 272) directly over the glued surfaces by placing blocks *A* between the work and the jaws as shown.

4. Prepare the material. Chamfer the trailing corners *B*, as shown in Fig. 273, to prevent splintering, and mount the material upon a face plate.

5. Turn to the greatest required thickness of the pattern. Upon the face scribe arcs of a circumference the diameter of which equals the distance across the points of the pattern. Turn work to this dimension.

Care should always be taken that the tool does not catch in the work in scribing a line upon or turning an interrupted surface.

6. Scribe upon the face of the work a circumference that is the diameter of the bolt hole and a circumference the diameter of which equals the distance across the corners of the octagonal-shaped boss.

7. Scribe upon the end surfaces of the material a distance representing the thickness of the points *C*; then turn the points of the pattern to their diminishing thickness.

8. Scribe the center lines *DD*, and lay out the shape of the patterns. The work at this stage of completion is illustrated in Fig. 273.

9. Turn the hole to shape, and sandpaper the wall. Refer to instructions on draft allowance upon the walls of small holes (page 50).

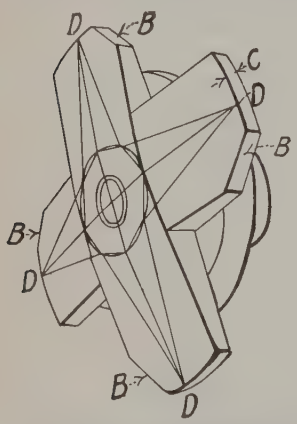


Fig. 273.—Shows the material turned to its diminishing thickness and the shape of the pattern laid out.

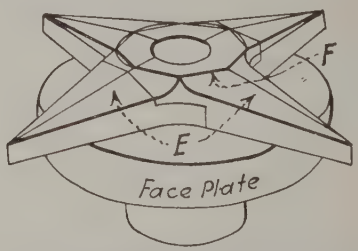


Fig. 274.—Shows the work remounted upon the face plate for the carving to shape of the boss.

10. Detach the work from the face plate, and saw the points to shape; then dress their edge surfaces.

11. Lay out the diminishing width of the edge surfaces of the points; then reattach to the face plate, as shown in Fig. 274. By reattaching the work to the face plate, the work can be easily secured in the vise, while the handwork is completed.

12. Dress to shape the top surface *E* of the points as shown. Fillets of $\frac{3}{8}$-inch radius, as indicated by *F*, connect the surfaces *E* with the outline of the boss.

13. Finish the pattern in the usual way.

PATTERN 38

TOOL REST

Features presented:

Mounting castings for the operation of machine finish
A pattern layout
The dowel joint
Shaping pattern
Application of countersawing

Figure 275 is the drawing of a cast-iron tool rest. The casting consists of a post supporting a crossbar.

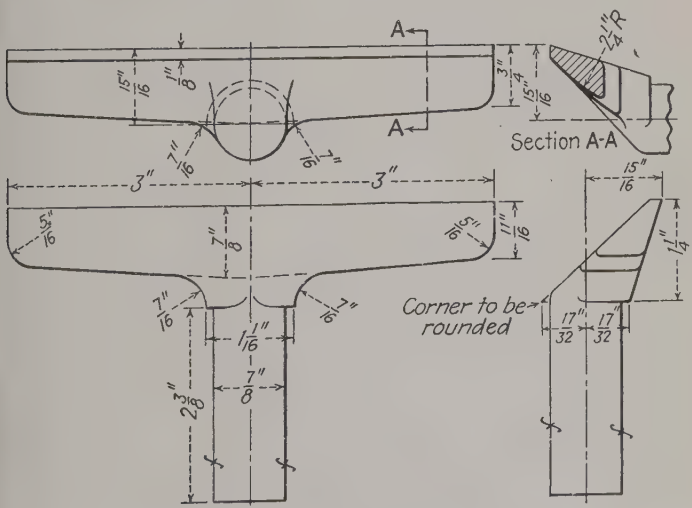


Fig. 275.

Where the finished surface of the post joins the fillet connecting the bar, a shoulder is formed. The width of the shoulder is $\frac{3}{32}$ inch and represents the amount of finish

allowance removed in finishing the diameter of the post. Ordinarily, $\frac{3}{32}$-inch finish allowance is not enough for the general run of iron castings; however, it will be found sufficient for a casting of this size.

The finishing of the post forms a sharp edge or fin, as shown in Fig. 275. A note specifies that the corner is to be rounded. This is a machine-shop operation.

Frequently, to facilitate mounting or holding work in performing a machine operation, a lug or projection unnecessary in the finished product, and not shown on the drawing, is to be provided upon the casting. If an addition of this kind is later found to detract from the appearance of the finished work, it is removed.

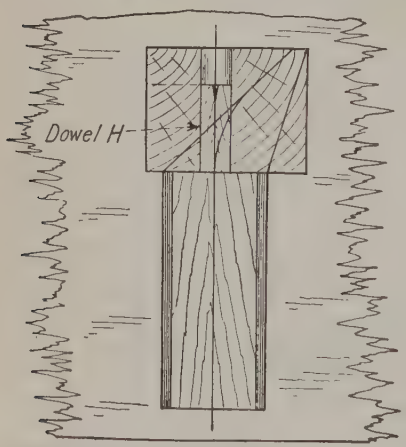


FIG. 276.—The layout of the tool-rest pattern showing how the post and crossbar members are attached.

Such provision should be indicated on the drawing, but if not so done, there is no excuse for its not appearing on the casting, since an efficient workman always feels that his responsibility ceases only at the completion of the finished product.

Therefore a patternmaker should consider not only the pattern and its mold but the way the casting is to be machined. For this reason a patternmaker should be familiar with the various machine-shop tools and the methods of mounting work upon them.

The pattern for the tool rest presents such a feature. To turn the surface of the post, the casting is mounted between the centers of the lathe. Drilling and countersinking a hole for a lathe center in a slanting surface as presented by the top surface of the bar is not the most satisfactory method and should

be avoided. Whenever a condition of this sort arises, a centering lug or boss, as shown at *H* (Fig. 279), should be provided upon the surface.

A layout of the end view of the pattern (Fig. 276) clearly shows the arrangement of the dowel joint. The dowel turned upon the end of the post portion of the pattern affords the means of securing the parts together. The dowel is made to protrude beyond the slanting surface of the bar and thus form the centering lug *H* (Fig. 279).

Better results will usually be obtained if the hole be bored in the crossbar material and the dowel of the post turned to fit into it. This fitting operation will require that the diameter of the dowel be continued to the dead center of the lathe. Turning under these conditions necessitates care to prevent the wood from splitting.

Stock required: $1\frac{3}{8} \times 1\frac{5}{8} \times 6\frac{1}{2}$ inches Bar
$1\frac{3}{8} \times 1\frac{3}{8} \times 3\frac{3}{4}$ inches Post

ORDER OF OPERATIONS

1. Turn the post to shape. Make the dowel $\frac{5}{16}$ inch in diameter and $\frac{7}{8}$ inch in length.

2. Dress the material for the bar to the required thickness and length (width unimportant).

3. Scribe the longitudinal and transverse center lines.

4. Bore the hole in the bar material that is to receive the dowel of the post. The position of the hole is more accurately produced if it is bored from each face of the material to the center of its thickness.

5. Place post and bar together in their relative positions, and trace the circumference of the post upon the surface of the bar.

6. Lay out upon each end of the material the end view of the bar.

7. Lay out upon one of the edge surfaces the front view of the bar.

8. Lay out the top view of the bar upon the surface of the material that is adjacent to the post.

9. From each end of the material, make saw cuts as at *E* (Fig. 277) along the lines representing the top view of the bar and along the lines representing the front view of the bar. The saw cut stops at the point *G*, where the fillet that connects the surfaces of the bar with the surface of the post begins.

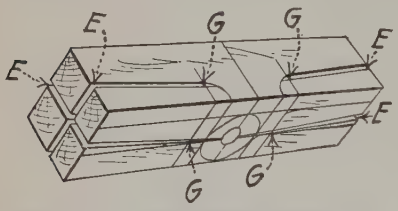


FIG. 277.—The crossbar member at the completion of the countersawing operation.

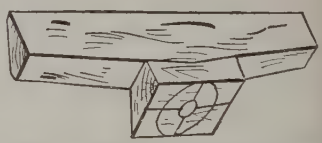


FIG. 278.—The crossbar as shown here has been dressed to its rectangular cross section and the waste material cut away.

This outline of the bar is countersawed at this time because the laying-out and sawing operation is more easily done while the material is of rectangular cross section.

10. Dress the material to the triangular cross section of the bar as represented by the layout.

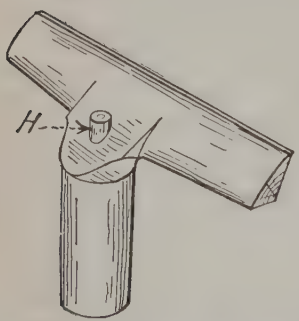


FIG. 279.—The post and partially shaped crossbar attached.

11. Complete with the saw the separation of the waste material. The bar at the completion of this operation is shown in Fig. 278.

12. Dress to shape the convex surface of the bar as shown by the cross section *AA* (Fig. 275).

13. Roughly shape the fillet with a knife, and glue parts together. The pattern at this stage of completion is illustrated in Fig. 279.

14. Complete the shape of the crossbar. The convex surface of this member is made to disappear gradually into the slanting surface of the bar lying above the post.

MOUNTING THE MATERIAL FOR TURNING PARTED PATTERNS

Figure 280 illustrates four methods whereby two pieces of material may be secured together and turned in the ordinary way.

Illustration *A* shows how screws are inserted beyond the limits of the pattern in the waste material. The screws should be placed at least ¾ inch from the end of the material. About 1½ inches of waste should be allowed at each end of the work.

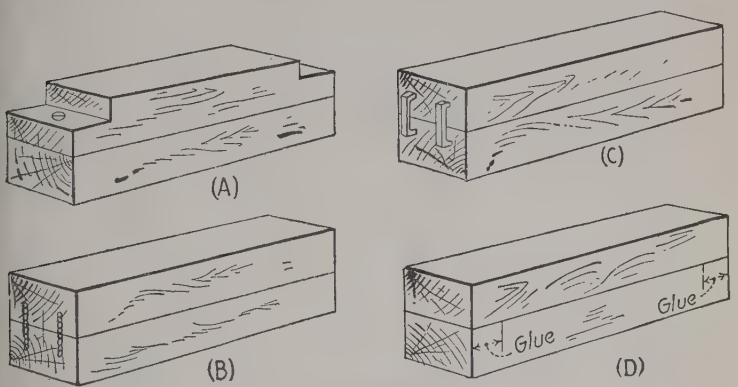


FIG. 280.—Four methods of securing together the material for parted patterns which are to be turned.

Corrugated fastener shown in Fig. 281 is a piece of corrugated sheet steel with one edge sharpened. Made in various lengths and widths, the size is designated by the length in inches and the width in the number of corrugations, as ½-inch No. 4 or ¾-inch No. 7. Corrugated fasteners are used to secure or reinforce the joint between two pieces of wood by driving the fastener so that one-half of its width will be on each side of the joint. The pieces to be secured should be held in contact while the fastener is being driven in.

FIG. 281.—Corrugated fastener.

Illustration *B* shows the application of corrugated fasteners. The fastener should be driven at about the middle of the

distance between the axis and the outer surface of the work. When used to hold two pieces together temporarily, as illustrated, the fastener is not to be driven in flush with the surface of the wood but allowed to project $\frac{1}{16}$ inch in order that it may be withdrawn later with a pair of pincers. Fasteners of $\frac{1}{2}$-inch length are best suited for work of this nature.

Pinch Dogs.—Pinch dogs, as shown in Fig. 282, are used largely when hand screws will not do. They are used to clamp together adjoining pieces of wood. The fact that the inside of the points or legs are tapered and the outside lies parallel causes the wood to be drawn together. The size is designated by the over-all length in inches. The sizes chiefly used, are 1, $1\frac{1}{2}$, and 2 inches.

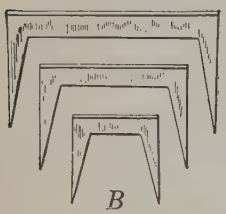


FIG. 282.—Pinch dogs.

Illustration *C* (Fig. 280) shows the application of pinch dogs.

Frequently it is found convenient to avoid the use of metal fasteners. The pieces are then secured together by applying glue to that portion of the parting surface which lies beyond the limits of the object to be turned (see illustration *D*). Sawing off the waste material will release the parts.

In turning small fragile patterns, a strip of paper glued between the parting surfaces at the center of its length will stiffen and prevent the pieces from separating. The pieces are easily separated by the insertion of a knife blade, leaving one-half the thickness of the paper adhering to each part.

A mistake frequently made is in not allowing, beyond the limits of the pattern, sufficient stock for securing the parts together. If dowel pins are required, they should be inserted before the material is secured together.

PATTERN 39

LEVER

Features presented:

Mounting castings for the operation of machine finish

Parted pattern turning

Figure 283 is the drawing of a cast-iron clamping lever. The casting consists of a handle supporting a boss. The handle portion of the pattern is turned; the boss is dressed to shape.

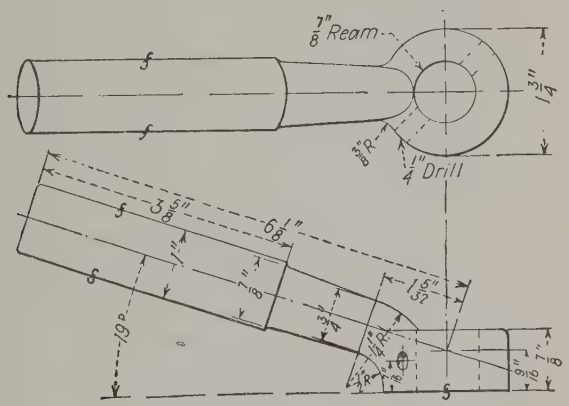


Fig. 283.

To turn the finished surface of the handle, the casting is mounted between the lathe centers. To eliminate the difficulty of countersinking into the cylindrical surface of the boss at an angle a hole to receive the lathe center, a centering lug (about $\frac{5}{16}$ inch in diameter), as indicated by *A* (Fig. 284), is provided upon the surface of the pattern at this point.

The drawing does not indicate that this provision for machining the casting is to be made. Refer to information

on the mounting of castings for the operation of machine finish given with pattern 38 (page 238).

A layout of the side view of the pattern is shown in Fig. 285. Although a layout in this case could be dispensed with, it will be found helpful in planning and dimensioning the pattern.

Patterns of a comparatively small diameter usually have the dowel pins set along their axis.

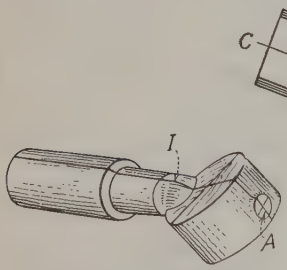


FIG. 284.—The completed pattern for the lever showing the centering boss *A*.

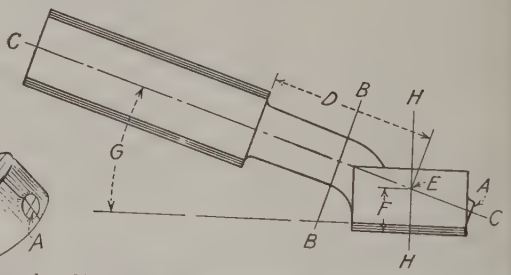


FIG. 285.—The layout of the pattern for the lever.

Stock required: $1 \times 2\frac{1}{4} \times 20\frac{1}{4}$ inches. The reference letters are not required on the layout but are used in this case as an aid to operations instructions.

ORDER OF OPERATIONS

1. Prepare the parting surface; set the dowels about $\frac{3}{4}$ inch in from the ends of the pattern; then secure the material together with corrugated fasteners. Corrugated fasteners afford the cheapest and the quickest means of securing the material together. They may be safely used for work of $2\frac{1}{2}$-inch diameter or less.

2. Locate and square around the material the line *B* of the layout. This line represents the limit of the turned portion of the pattern. Its location is to be established in correct relation to the dowel pins.

3. Center the work. This operation requires careful attention, for, unless the centers of the lathe are correctly located upon the parting joint, an unequal proportioning of the two parts of the pattern will result.

4. Complete the turned portion of the handle, and finish with one coat of shellac.

Caution: Parted work cannot be turned so close to the axial line as solid work because of the danger of the material breaking off.

5. Separate the work; then upon the parting surface of the drag half locate and scribe the center line *C* (Fig. 286). This center line is to be located from the extreme diameters of the turned portion. Never establish a center line from the impressions left upon the ends of the material by the lathe centers.

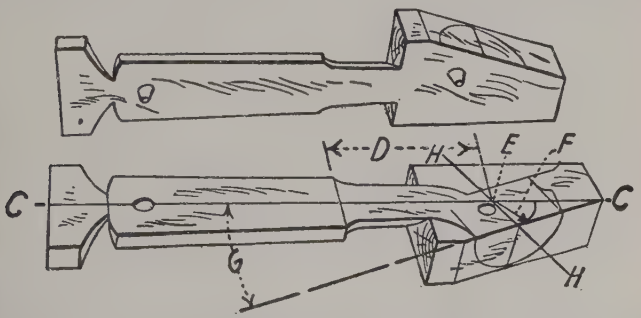


FIG. 286.—The lever pattern in course of shaping. The lathe work is completed, the layout of the boss made upon the parting surface, and the angle of the face of the boss established.

6. Lay off upon the center line *C* the dimension represented by *D*, obtaining the point *E*. Using this point as the center, with a radius equal to *F* of the layout, scribe an arc as shown.

7. Lay out the angle *G* that the face of the boss forms with the center line *C* of the handle. The angle is laid out by setting a bevel to the required number of degrees. To scribe this line, place the stock of the bevel along the center line *C* and the blade tangent to the arc *F*.

8. Dress the drag half of the material to this angle; then transfer the angle to the cope half. The surface produced represents the face of the boss.

9. Scribe the center line *H* of the boss; then, upon the surface that is to be the face of the boss, scribe a circumference the diameter of which is the diameter of the boss.

10. Make a layout of the boss upon the parting of the drag half of the material, as shown in Fig. 286.

11. Dress the material to the shape of the pattern as laid out; then trace its outline upon the cope half, and repeat the dressing operation.

12. Dress to shape, as at *I* (Fig. 284), that portion of the curved surface of the handle which intersects the top surface of the boss.

13. Upon the top surface of the boss, scribe its circumference and the outline of lug; then proceed to dress to shape.

The knife is the tool best adapted to the shaping of the fillet connecting the surface of the handle with the surface of the boss and the dressing to shape of the centering lug.

In shaping surfaces of this nature, an operation that depends greatly upon the eye, view the surfaces from different angles as the dressing progresses to see that they appear the same on each side of the center line.

PARTED MATERIAL ARRANGEMENT

Small parted irregular-shaped patterns, as that of a dumbbell, may be readily turned to shape without the use of templets if the material is arranged as shown in process in Fig. 287.

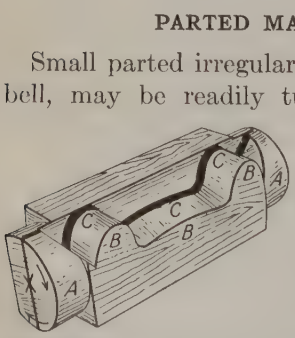


FIG. 287.—A parted material arrangement whereby patterns of an irregular shape may be turned without a templet.

From the short cylindrical surfaces *A* at the ends of the material, the axis of the work is located and a center line drawn throughout the length of the parting surface of one piece. Upon this surface, lay out a radial outline of the pattern, and carefully saw it to shape, as shown at *B*. The letter *C* calls attention to how a narrow strip of the sawed surface adjacent to the parting joint is blackened with crayon. By mounting the work in the position shown, the required shape of the pattern may be distinguished while the lathe is in rapid motion.

PATTERN 40

REDUCING CONNECTION

Features presented:

Flange insertion

Core-print proportioning

Figure 288 is the drawing of a cast-iron reducing connection consisting of a conical shell supporting a flange at each end.

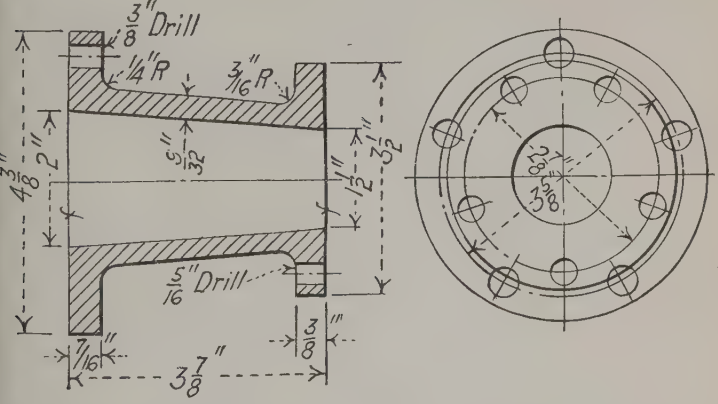


FIG. 288.

The pattern will be parted; core prints extending out from the ends of the pattern afford the means of supporting the core.

If the grain of the wood in the flanges is laid in the same direction as the grain of the wood in the body of the pattern, the flanges, because of the short grain, will be easily broken. This weakness is eliminated by arranging the material as illustrated in Fig. 289.

The flanges are made independent of the body, with the grain of the wood lying in a direction transverse to the grain of the wood in the pattern body. The flanges are attached by

setting them into the body as shown. *Inserting a flange* is the term used to express this method of construction.

The flanges are shown attached to the drag half of the pattern. Attention is called to the way in which the flanges are sawed out, permitting their edges, as indicated by *A*, to project above the parting in order that they may later be planed true to this surface. The flanges for the cope half of the pattern are shown above the groove into which they are to be inserted and glued.

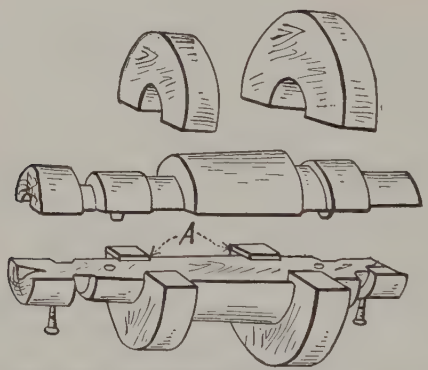


FIG. 289.—The body and flange material of the pattern in course of attaching.

The diameter of the grooves may be about $\frac{1}{4}$ inch less than the adjacent diameter of the core print. The width of the groove is equal to the thickness of the flange of the pattern plus the radius of the fillet.

For the length of the core prints, refer to the Table of Core-print Proportions (page 81). The taper of the core print is to be the same as the taper of the shell.

If the core prints were made of cylindrical form instead of conical, as shown in Fig. 290, it would not be helpful in the making or in the molding of the pattern, but it would add extra expense in making the core box. This feature is one that should always be considered, and the core-print portion of a pattern, whenever practicable, should be so shaped or arranged as to simplify the making of the core box.

The layout of the pattern, as shown in Fig. 290, is required in this case to determine the location and size of the grooves for the flanges and the proportioning of the core prints. It is also used as a reference from which the dimensions are taken and applied to the pattern.

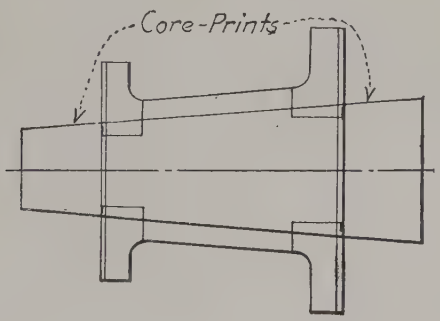


FIG. 290.—The layout of the pattern for the connection.

When locating the grooves, make an allowance of $\frac{1}{16}$ inch for turning the face surfaces of the flanges.

Stock required:

$1\frac{1}{2} \times 3 \times 18\frac{1}{4}$ inches	Body	Pattern
$\frac{7}{8} \times 2\frac{5}{8} \times 9\frac{1}{2}$ inches	Flange	Pattern
$\frac{3}{4} \times 2\frac{1}{8} \times 7\frac{1}{2}$ inches	Flange	Pattern
$1\frac{1}{2} \times 3\frac{1}{8} \times 6\frac{3}{4}$ inches	Core box	Core box
$\frac{3}{4} \times 1\frac{1}{2} \times 6\frac{3}{4}$ inches	Core box	Core box

ORDER OF OPERATIONS

1. Prepare the parting surface, and set the dowels.

2. Attach parts together with screws; then center and mount the work. Screws should always be used whenever the work, as in this case, is to be separated before the turning operation has been completed.

3. Turn the material down to the form of a cylinder.

Note: No dimension of the pattern is to be turned to the required size until the flanges are attached.

4. From the center of the length of the material, lay off on each side one-half of the over-all length of the body of the pattern; from these lines, lay off the width of the grooves.

5. Turn the grooves.

6. Remove work from the lathe, and separate the parts.

7. Prepare and saw the flange material to shape, allowing ¼ inch on their diameters for the turning operation. The concave joint surfaces should be so sawed as to require no further work to make the parts fit correctly together.

8. Attach the flange material with glue and brads. Drive the brads through the flange from the face adjacent to the core print. Set the heads of the brads below the surface so that they will not come in contact with the turning tool.

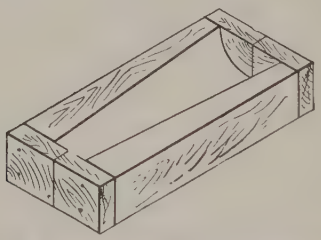


FIG. 291.—The core box used with the connection pattern.

In preparing the parting surfaces of the flanges, make certain that these surfaces are in contact throughout their length. This is necessary in order to avoid the splintering of the edges of the parting surfaces.

9. Remount the work, and proceed with the turning operation.

Use the calipers for testing the distance between the face surfaces of the flanges.

All dimensions are to be transferred from the layout board.

Turn the waste material at the end of the core prints to about 1 inch in diameter.

The core box for the reducing connection is illustrated in Fig. 291.

PATTERN 41

SOCKET BASE

Features presented:
Core-print proportioning
Registering a core
Application of dowel pins

Figure 292 is the drawing of a cast-iron socket base.

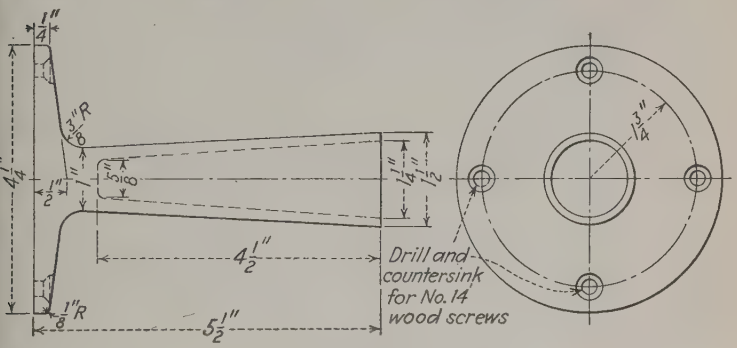


FIG. 292.

The base is secured to a wooden shaft by means of a blind socket. The blind socket is formed in the casting by a core placed in the mold as shown in Fig. 293.

When a core receives support from only one end, as in this case, it is sometimes called a *balanced core*.

The core print must be so arranged and proportioned that the print part of the core will not only overbalance that portion of the core which extends into the metal cavity, but also prevent the core from rising when pressure is exerted from below by the inflowing metal.

It will be noted that the diameter of the core print is made greater than the adjacent diameter of the pattern. Enlarging

the diameter of the print in this way has two advantages: it gives greater seating surface, with less length of print, and it provides a shoulder at *A* (Fig. 293) that assures the correct registering of the core in the mold.

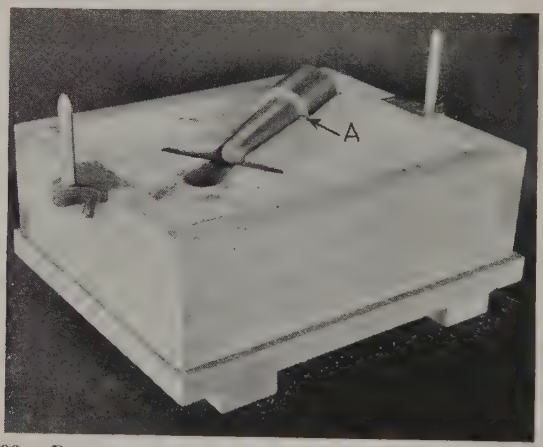


FIG. 293.—Drag part of the socket-base mold showing core in place.

The pattern in process of making is shown in Fig. 294. The body and the flange material for one-half the pattern are shown attached. The neck *B* is the means of attaching the parts together.

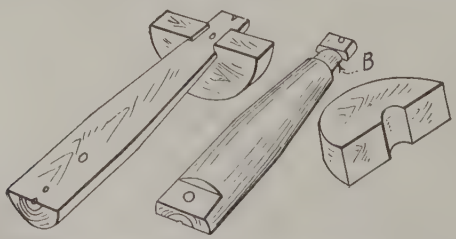


FIG. 294.—The body and flange material of the pattern in course of attaching.

A layout of the pattern is required to determine the proportions of the neck, the core print, and the sizes of stock required.

Make the core print about $1\frac{7}{8}$ inches in diameter and 3 inches long. Make the diameter of the neck $\frac{3}{4}$ inch.

Stock required: $1\frac{1}{8} \times 2\frac{1}{4} \times 22$ inches Body, $1 \times 2\frac{3}{8} \times 9\frac{1}{4}$ inches Flange } Pattern

$1\frac{1}{2} \times 3 \times 5$ inches, $1\frac{1}{2} \times 3 \times 3\frac{1}{2}$ inches, $\frac{3}{4} \times 1\frac{1}{2} \times 7$ inches } Core box

ORDER OF OPERATIONS

1. Prepare the parting surface, and set a dowel at the core-print end of the pattern.

2. Attach parts together with screws; then center and mount the work. Core print toward live center.

3. Turn the material down to the form of a cylinder; then locate and lay off the length of the neck.

4. Turn the neck to size; then roughly turn the material to the shape shown in Fig. 294. Turn no part of the pattern to required size until the flange is attached.

5. Remove work from the lathe; bore the dowel-pin hole through the neck; then separate the parts. In order that the dowel may not interfere with the planing operation, the dowel must not be set until the flange is attached and the parting surface prepared. This dowel should not exceed $\frac{1}{4}$ inch in diameter, since a larger dowel would weaken the pattern at this point.

6. Prepare and attach the flange material. Allow $\frac{1}{8}$ inch on the radius of the flange material for the turning of this surface. Refer to the information on flange insertion given with pattern 40 (page 247) Because of the small joint surface obtained between the surface of the neck and the flange, it is important that a good joint be made. At the completion of the turning, the joint may be reinforced with brads driven through the neck.

7. Prepare the parting surfaces of the flanges; then set the dowel in the neck, and reattach parts. A spot of glue applied to the parting surfaces of the flange material beyond the limit of the pattern will help to keep the parts together during the roughing-down operation.

Refer to the information on securing together the material for turning fragile parted patterns (page 241).

8. Turn the face of the flange, then the diameter. Scribe upon the circumference of the flange the edge thickness of this member. Roughly shape the back surface of the flange.

9. Turn to the small diameter of the socket portion of the pattern; then turn the back surface of the flange to shape.

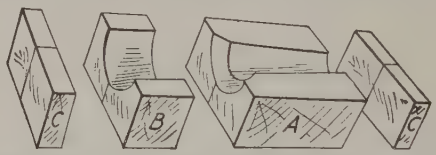


FIG. 295.—The parts of the core box shaped and ready to be attached together.

When the diameters of the members of a pattern differ greatly, as in the case of the small diameter of the socket portion of the pattern and the flange, the shape of the larger member should be turned first, since this order of operation tends to eliminate vibration.

10. From the face of the flange, lay off the over-all length of the pattern, and proceed to turn this part of the pattern to shape.

Figure 295 shows the parts of the core box for the socket base as they will appear when dressed to shape and ready to be assembled.

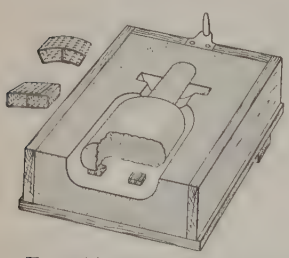


FIG. 296.—Shows how chaplets may be used to assist in holding a core in place when the core-print seat is insufficient.

Chaplets.—When the core print of a pattern does not provide ample support or hold a core in place, chaplets are used, these metal supports being placed between the core and the wall of the mold, as shown in Fig. 296. The selection of chaplets as to weight and type will depend upon the metal thickness of the casting. For in use, chaplets are intended to hold cores in place until after the pouring of the mold. Then, during the solidifying of the metal, the chaplets are fused into this body.

PATTERN 42

CARBURETOR CONNECTION

Features presented:

✓ Flange insertion.

Application of templets.

Application of the dowel joint.

Core-box construction.

Spoon gouge.

Figure 297 is the drawing of a cast-iron carburetor connection, consisting of a shell supporting a flange at each end. The faces of the flanges lie at right angles to each other.

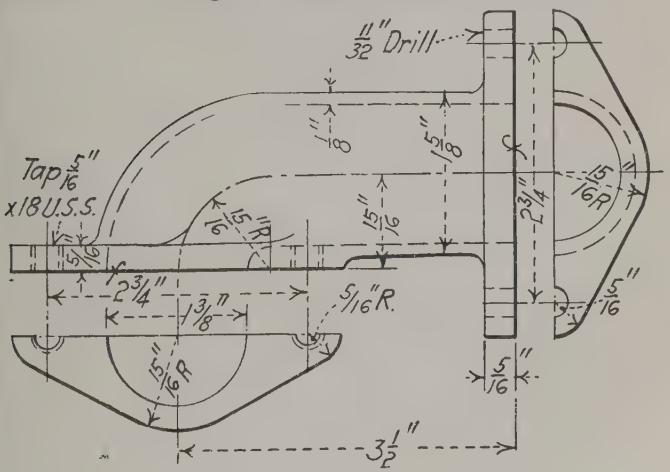


Fig. 297.

When a view of a casting is the same or symmetrical about a center line, as in this case, only a one-half view of the casting is required as shown.

A layout of the pattern, as shown in Fig. 298, is necessary in order to determine the arrangement of the joints between the

pattern members. The pattern is parted. Core prints extending out from the face of the flanges afford the means of supporting the core.

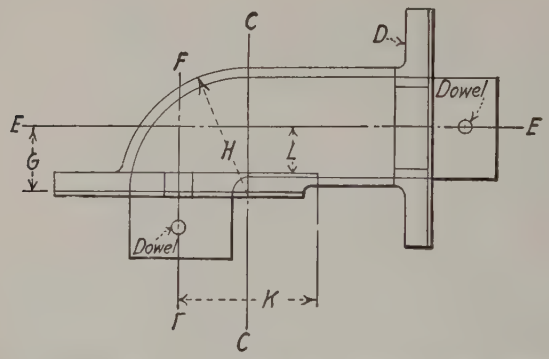


FIG. 298.—The layout of the pattern for the carburetor connection.

Stock required:

1 × 2¼ × 17 inches	Body	Pattern
⅝ × 2 × 8 inches	Flange *B*	Pattern
½ × 1¼ × 7½ inches	Flange *J*	Pattern
⅞ × 1¾ × 9 inches	Core print *M*	Pattern
1⅛ × 4½ × 13 inches		Core box
11/16 × 1⅛ × 15 inches		Core box

ORDER OF OPERATIONS

1. Prepare the material for the body of the pattern. For the location of dowels, see layout.

2. Locate and scribe around the material the line *C* of the layout.

This line represents the limit of the turned portion of the body.

3. Turn the cylindrical portion of the body to approximately 1¾ inches in diameter. Locate and turn the groove that is to receive the flange *D*.

The material for this flange is sawed out, attached, and turned in the same way as a flange of circular form.

4. Insert the flange; then remount the work, and complete the turning operation. Turn the diameter of the flange material to about $3\frac{5}{8}$ inches.

5. Lay out and cut from thin material or heavy paper, as shown in Fig. 299, a templet corresponding in form to one-half of the flange. The radius of the semicircular shape of the templet is equal to the radius of the core print. It is the means of registering the templet in transferring its outline to the face of the flange. Dress the flange to this shape.

FIG. 299.—Templet used in tracing upon the material the shape of the flange.

6. Locate and scribe upon the parting of the drag half the center lines *E* and *F*.

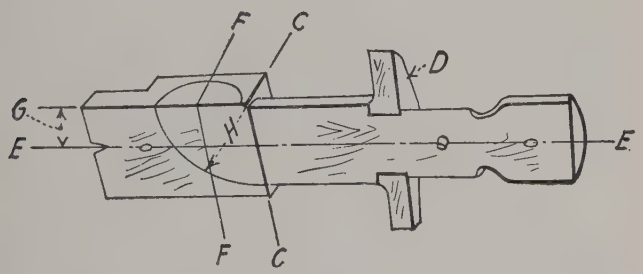


FIG. 300.—The cope half of the pattern at one stage of completion.

7. Lay off the distance represented by *G*, and dress both halves of the material to this width.

8. Place the parts together and, using the intersection of the center line *F* with the parting line as a center, scribe upon this surface a circumference, the diameter of which equals the diameter of the shell. From the intersection of this circumference with the parting line, scribe upon the parting surface the arc *H*.

The cope half of the pattern at this stage of completion is shown in Fig. 300.

9. Saw and dress the material to the outline of radius *H*.

10. Gage about the edge surface of the material a distance equal to the semidiameter of the shell, and dress the material to this thickness.

11. Dress the bend to shape. Figure 301 shows this work being done with the spoke shave. The surface of the material is first dressed to the shape of an octagon, as shown. Then, with the aid of the templet shown in Fig. 302, the dressing of the surface is carried to completion. A block screwed to the work affords a means of holding it in a hand screw.

12. Prepare the joint surface to receive the flange material *J* (Fig. 303), using the dimensions *K* and *L* (Fig. 298) of the lay-out. The drag half of the pattern at this stage of completion is shown in Fig. 303.

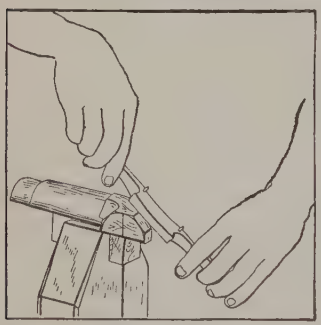


FIG. 301.—Shaping the surface of the bend with a spoke shave.

13. Fit the material for flange *J* into place; then lay out, and dress the flange to the shape shown. Dress to shape the hole through the flange that is to receive the dowel of the core print *M*. Then attach the flange material. The end *O* of the flange is dressed to conform to the cylindrical surface of the shell.

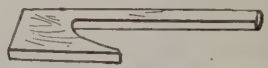


FIG. 302.—Templet used in testing the surface of the bend while being shaped.

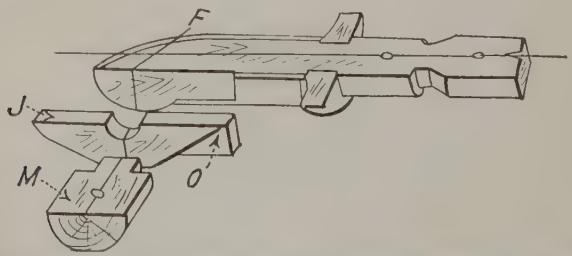


FIG. 303.—Members of the drag half of the pattern shaped and ready to be attached together.

Because of the shape of the core and the position of the two points of support, the print *M* is to be made ¾ inch longer than the length prescribed by the Table of Core-print Proportions.

CORE BOX FOR CARBURETOR-CONNECTION PATTERN

The dry-sand core that forms the interior shape of the carburetor connection and the box in which one-half of the core is formed are shown in Fig. 304.

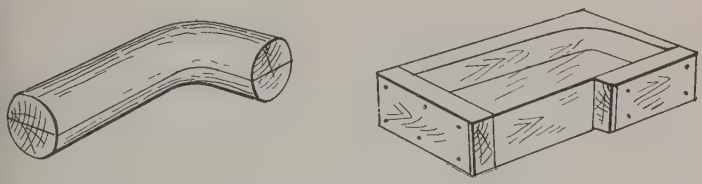


FIG. 304.—The core and one of the core boxes used in connection with the pattern.

The right-hand and left-hand boxes, as they are usually called, are shown in process of making in Fig. 305.

To assure uniformity in the layout of the two core cavities, the material is doweled together as shown.

Transfer distances *C* and *D* from the pattern; then scribe the center lines of the core cavity upon the parting surface and upon the edge and end surfaces of one piece of the material.

Place the two pieces together, and at the intersection of the center line and the parting line scribe upon one edge and end a circumference, the diameter of which equals the diameter of the core cavity.

Upon the parting surface of both pieces, lay out the shape of the core cavity. One-half of the box is shown at this stage of completion.

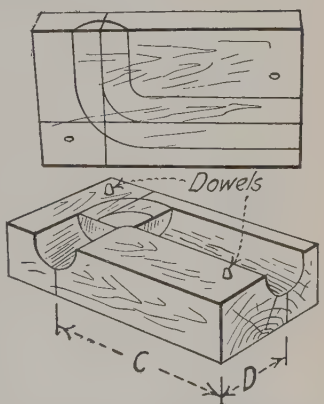


FIG. 305.—Shows the right- and left-hand core boxes for the carburetor connection in process of shaping.

Dress the semicircular portions of the core cavity to the required shape. One-half of the box is shown at this stage of completion.

Spoon Gouge.—The surface of the bend is dressed to shape with a spoon gouge or a firmer gouge. A spoon gouge is shown in Fig. 306.

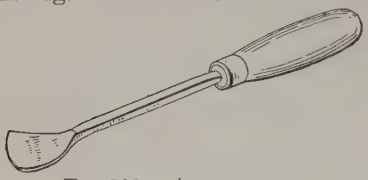


FIG. 306.—A spoon gouge.

Sandpaper the surface of the core cavity; then close the ends as shown.

Cut off and plug the dowel holes, and finish boxes as instructed.

QUESTIONS

1. What is the object in half-lapping the material for the star-washer pattern?

2. What means may be provided to facilitate the drilling of a hole in a sloping or cylindrical surface of a casting?

3. Why should a patternmaker be familiar with the methods of mounting castings for the operation of machine finish?

4. What is a dowel joint?

5. Describe a corrugated fastener, and explain its use.

6. How is the size of corrugated fasteners specified?

7. What is a pinch dog? Explain its action.

8. Explain how glue may be used to secure together material for a parted turned pattern.

9. What feature not shown on the drawing of the lever is to be provided upon the casting?

10. Why should the centering of the material for a parted turned pattern receive careful attention?

11. What is understood by the term *flange insertion?*

12. When is the feature termed *flange insertion* applied to a pattern?

13. What advantage is gained by making the taper of the core prints of the reducing connection pattern the same as that of the body of the pattern?

14. What is the means used to register the core in the mold for the socket-base casting?

15. How should a core print be proportioned for a core lying horizontally in the mold and receiving its support from one end?

16. Why should the flange of the socket-base pattern be turned before the socket portion?

17. For what purpose is the spoon gouge used?

PATTERN 43

GLUE POT

Features presented:

✓Application of the suspended core

Pattern arrangement

Turning parted work upon a face plate

Core-box construction

Figure 307 is the drawing of a cast-iron glue pot.

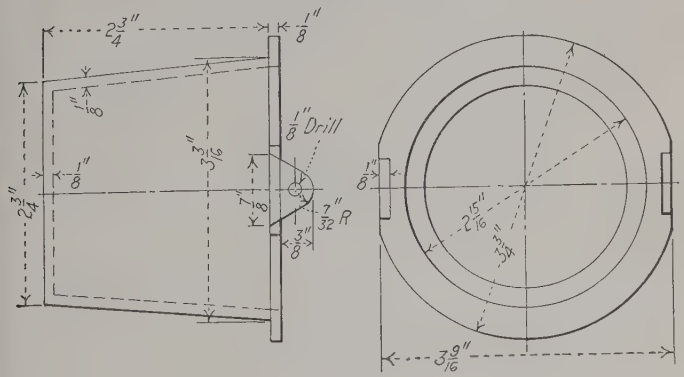


Fig. 307.

When a casting is of a cross section similar to that of the glue pot, the interior of the casting may be formed by a core suspended from above the mold, as illustrated in Fig. 308. A core print extending out beyond the flange of the pattern forms a seat at *B*, which registers and supports the core. The contact between the parting surface of the cope and the top surface of the core holds the core in place.

The cavity of the mold that forms one of the ears of the casting is shown at *C*. The impression of the ear is formed in

the core. The width of the core at D is the distance between the outer faces of the ears.

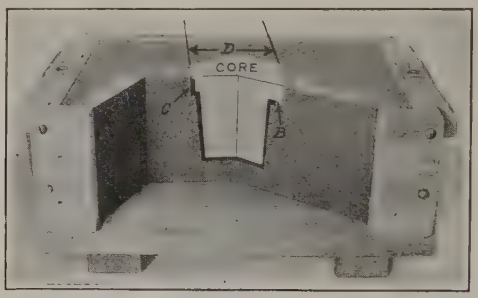


FIG. 308.—A sectional view of the mold for the glue pot with the suspended core in place.

The pattern is illustrated in Fig. 309.

The core print is made to extend about $\frac{1}{4}$ inch beyond the flange of the pattern at A. The thickness of the core print is made about $\frac{5}{8}$ inch. To assist the setting of the core, a $\frac{1}{8}$-inch slant is given the edge of the core print; this does not apply to the edge surfaces of the core print at E, since only a slight draft is given these surfaces.

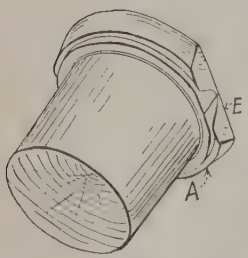


FIG. 309.—The arrangement of the core print of glue-pot pattern.

The grain of the wood that forms the core print and flange lies in a direction transverse to that of the grain of the wood in the body of the pattern.

Stock required: $3\frac{3}{4} \times 3\frac{3}{4} \times 3\frac{1}{4}$ inches, $1\frac{3}{16} \times 4\frac{3}{4} \times 4\frac{3}{4}$ inches } Pattern

$2\frac{3}{4} \times 4 \times 12\frac{1}{2}$ inches } Core box

CORE BOX FOR GLUE-POT PATTERN

The core box in course of making is shown in Fig. 310. One-half of the box has been removed from the face plate and the work carried to completion. The other half of the box shows the material G directly above its location in the core cavity. For the purpose of illustration, the ear is shown attached.

ORDER OF OPERATIONS

1. Attach to a face plate a thickness of facing material. True up the face; then scribe across this surface in a direction transverse to the grain of the wood a line passing through the center of rotation.

Whenever securing parted material to a face plate, always place the line of parting in a direction transverse to the grain of the wood of the facing material. Placing the direction of grain of the wood at right angles gives added strength and

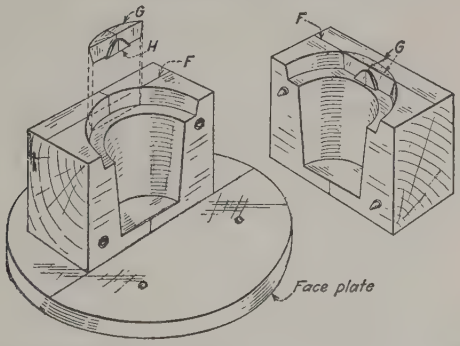


FIG. 310.—The arrangement of the core box used in connection with the glue-pot pattern.

eliminates any danger of the facing material splitting along the line of the parting of the pattern material.

2. Prepare the material, and set the dowels at about the location shown.

3. Select one-half of the material, and set the edge of the parting surface to the line scribed across the face of the plate. A hand screw may be used to good advantage for holding the material in place while the screws are being driven. Each half is to be secured with two screws.

The parting surface of the material must set perpendicular to the face of the plate in order that the center of rotation may occur throughout the parting line.

4. Clamp the two parts together, and attach the other half of the material to the face plate. The material should be further

secured by pinch dogs. Drive the dogs into the ends of the material about 1 inch back from the face of the work.

5. True up the face of the material; then scribe a line through the center of rotation and at right angles to the parting line.

6. Locate and scribe, parallel to the parting, the lines *F*, which represent the position of the outer face of the ears.

7. Scribe upon the face of the material a circumference whose diameter is that of the core print of the pattern.

8. Turn out the core-print portion of the box to shape. Scribe circumferences upon this depressed surface to represent the diameter at the top and the diameter at the bottom of the core cavity.

Owing to the depth of the cavity it is of the utmost importance that the edge of the tool rest is kept parallel to the surface being turned. As the turning progresses, the tool rest is moved farther into the cavity.

9. Fit the material for the pieces *G* into place. Make the pieces of ample width so that they may be held in place in order that the line *F* may be transferred to their top surface.

10. Dress the ears to shape, sandpaper their edge surfaces, and attach to pieces *G*.

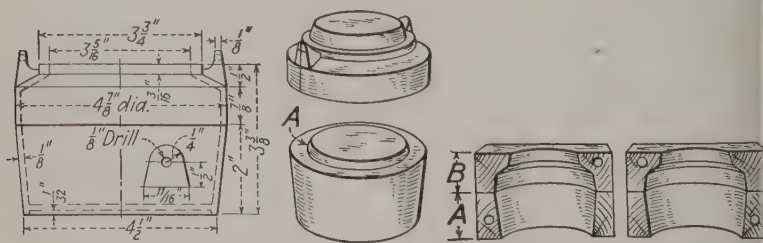


FIG. 311.—Water jacket pattern.

WATER-JACKET PATTERN

Figure 311 is the drawing and the pattern requirements for making the water jacket for the glue pot. The two parts of the pattern are registered by a matched surface formed by the projection *A* and a corresponding depression in the drag surface. Parts *A* and *B* of the core box are turned separately and attached as shown.

Matched parting

PATTERN 44

AIR CHAMBER

Features presented:

Plaster-of-Paris core boxes

Figure 312 is the drawing of a brass air chamber. The metal thickness of the casting is approximately $\frac{5}{32}$ inch throughout. Little variation should occur in the metal thickness of castings of a thin-shell nature, a feature demanding a close degree of accuracy in the making of the pattern and its core box.

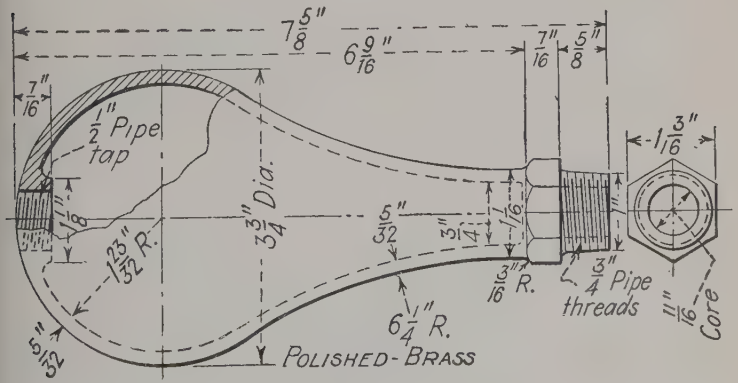


FIG. 312.

For core boxes of certain form, when a small number of cores are needed, the accuracy requirements of the core box are more easily obtained by making the box of plaster of Paris.

Frequently the design of a casting calls for a slight protrusion such as the 1⅛-inch boss on the interior of the air chamber. To form this boss in the core would necessitate a loose piece in the core box. Whenever the added thickness of metal is

of no importance, the face of the boss may be extended to the width of the cavity at this point, as shown in Fig. 314.

To make the pattern shown in Fig. 313 is a simple lathe job and requires no explanation.

To make the plaster cast or core box shown in Fig. 314, a parted model or form is turned to the exact dimensions of the

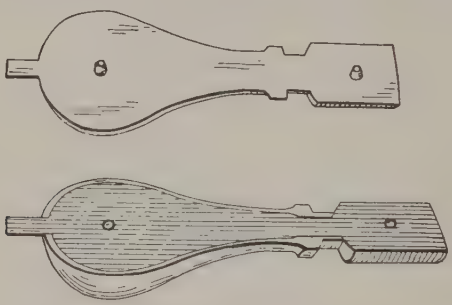


FIG. 313.—The pattern for air chamber.

required core and finished with at least two coatings of shellac. One-half of this form is then attached with screws to the surface of a board (shellacked surface), as shown in Fig. 315, and a frame arranged about it. The frame should be so proportioned as to provide about ½ inch as the minimum thickness of plaster about the form.

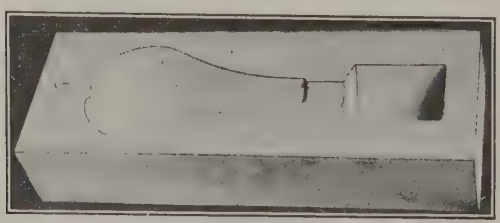


FIG. 314.—The plaster core box.

It is very important that all surfaces that would lie perpendicular to the surface of the board be given a liberal draft allowance. Never attempt to make a cast without applying a coating of machine oil to the surface of the form and surface of the board.

Use only a good grade of plaster. The grade used by dentists will give the best results. Its consistency for pouring should be like that of heavy cream. Always add the plaster to the water. Stir slowly, and pour likewise, so as to avoid as far as possible the presence of air bubbles, which, if carried into the mold, will result in pitted surfaces. Pour the plaster back and forth slowly over the form. Avoid any splashing. If the frame contains any offsets or pockets where air might be trapped by the inflowing plaster, release the air by slowly churning the plaster with a small stick about these locations.

Allow about 20 to 25 minutes for the plaster to set. Then remove the frame, and detach the form from the board.

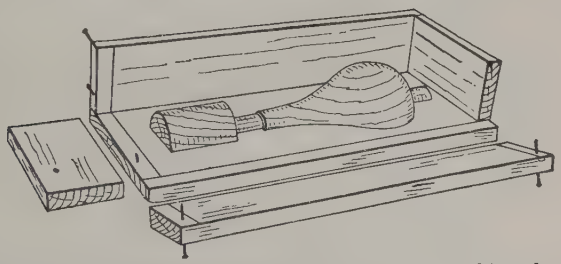


FIG. 315.—The arrangement of form and frame for making the cast.

Remove the form from the plaster with the aid of a wood screw. Never allow a form to remain in the plaster longer than is necessary, for the moisture will very probably cause the form to swell and prevent its removal without defacement of the cast.

Ample time should be allowed for the cast to attain the maximum degree of dryness (about 48 hours) before coating its face surface with shellac.

Metal core boxes are usually made when a great number of cores are required. In such cases, the cast is made as herewith described. The excess plaster is then cut away until the desired thickness of metal and exterior shape of the plaster pattern have been obtained.

Forms for patterns for metal core boxes require a double contraction allowance.

PATTERN 45

PISTON

Features presented:

Application of the suspended core
Counter drilling of cored holes
Core-box arrangement
The Forstner bit

Figure 316 is the drawing of a cast-iron piston.

In making the pattern for the piston casting shown, no consideration is to be given to the $2\frac{1}{2}$-inch-diameter recess at

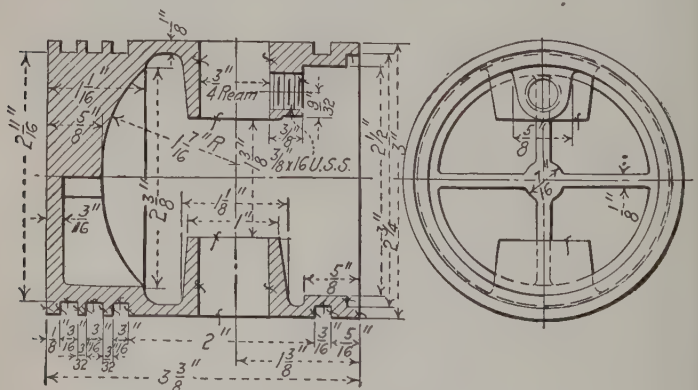


Fig. 316.

the open end or the four ring grooves. The forming of these grooves is a machine-shop operation. The $\frac{3}{4}$-inch-diameter hole for the wrist pin could be cored of a diameter that would permit it to be counterdrilled. This would likely be the procedure in the case of nonferrous metal but would not be found so satisfactory with cast iron.

Here again, as in the case of the mold for the glue-pot casting, the suspended-core feature is involved since it will ensure an even wall thickness of the piston. This molding position will also cause any impurities in the molten metal to rise to the cope surface where ample finish allowance can be provided for the removal of this layer of porous metal.

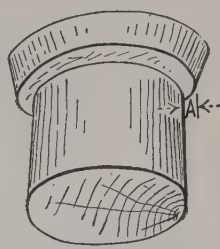


FIG. 317.—The pattern for the piston showing the arrangement of the core print.

The core print of the pattern shown in Fig. 317 overhangs the cylindrical body about ½ inch as at *A* and thereby forms a supporting seat for the core within the mold. An angle of about 15 degrees is to be given to the diameter of the core print.

Stock required:

$3\frac{3}{4} \times 3\frac{3}{4} \times 4$	inches	Pattern
$\frac{3}{4} \times 4 \times 4$	inches	Pattern
$1\frac{5}{8} \times 5\frac{1}{2} \times 5\frac{1}{2}$	inches	Core box
$1\frac{5}{8} \times 2\frac{7}{8} \times 11\frac{1}{2}$	inches	Core box
$1\frac{3}{8} \times 2\frac{7}{8} \times 11\frac{1}{2}$	inches	Core box

Figure 318 illustrates the core box. To show better the interior of the core cavity, a part of the box has been removed.

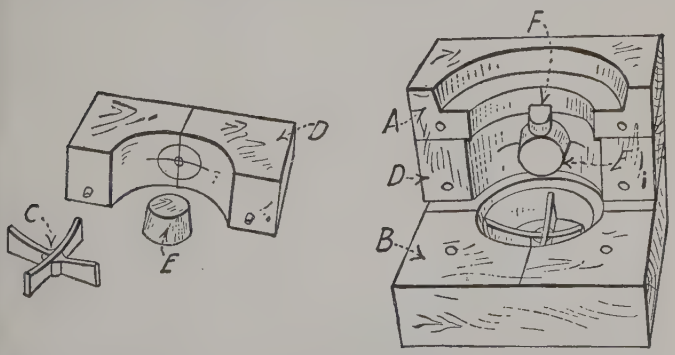


FIG. 318.—The core box for the piston pattern in course of assembling.

Part *A* of the box is turned. The depression in part *B* of the box is turned. The ribs are made as shown at *C* and attached in place. Part *D* is sawed to shape. Bosses *E* may be turned

or sawed and sanded to shape and glued to part *D*. Lug *F* is made and attached to boss *E*.

The Forstner Bit.—The Forstner bit, as shown in Fig. 319, is so designed that it bores a hole with a flat bottom. This feature makes this type of bit well adapted for forming seats for small round bosses in concave or convex surfaces. It is also used to good advantage in removing the excess waste from an enclosed depressed surface that is to be finished with the router.

FIG. 319.—The Forstner bit.

With a 1⅛-inch Forstner bit, form seats to receive the bosses *E*. This method of attaching bosses of a small diameter to a curved surface is in most cases preferable to dressing the boss to fit the surface.

Frequently it is advantageous to locate the material of a boss and dress it to shape after the material is in place. In this case, the material is made about ⅛ inch greater in diameter than the required diameter of the boss.

QUESTIONS

1. What is understood by a suspended core?

2. What should be carefully noted in regard to the axis of the work in locating parted material upon a face plate?

3. What feature should be noted whenever attaching parted material to the facing material of a face plate?

4. For what purpose are chaplets used?

5. How may small irregular-shaped parted patterns be turned without the aid of templets?

6. What is understood by a matched parting surface?

7. What is gained by making a plaster-of-Paris core box?

8. Why should plaster be stirred slowly and poured likewise?

9. How may bubbles trapped in the plaster during pouring be released?

10. Why should the form be removed from the plaster as soon after pouring as possible?

11. How should the surfaces of the form and the board be prepared to prevent adhesion?

12. What is the distinct feature of the Forstner bit?

13. For what purpose is the Forstner bit particularly adapted?

PATTERN 46

HANDWHEEL

Features presented:

Loose ring feature

Application of templets

Figure 320 is the drawing of a cast-iron handwheel.

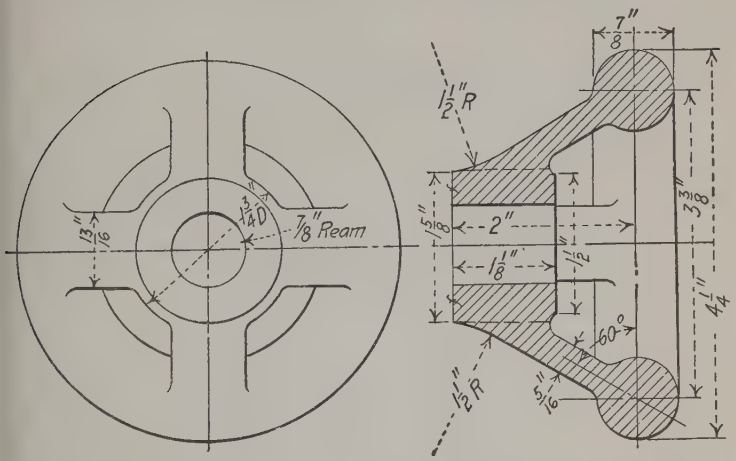


Fig. 320.

Frequently there occurs around the inside of a pattern or a core box a ring or projection that the molding operation requires to be made loose. If the pattern for the handwheel were made solid, the rim would not permit the sand that takes the impression of the inside of the pattern to be coped out; therefore a part of the rim is made a loose piece.

Figure 321 shows the layout of the work. It is required in determining the position of the joint between the loose ring and the body of the pattern and in the dimensioning of the pattern.

Figure 322 illustrates the mold; the pattern is shown in the sand. In order to remove the loose ring from the body of sand in which it is imbedded, it is parted as at *A*.

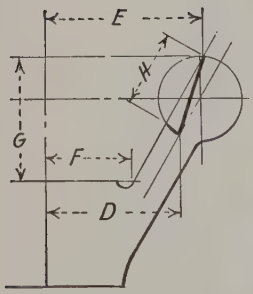


FIG. 321.—The layout of the handwheel pattern.

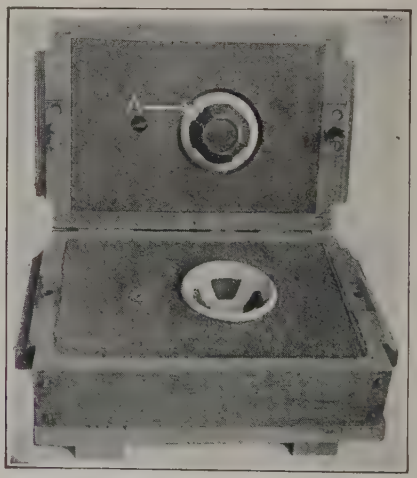


FIG. 322.—Shows the mold for the handwheel upon lifting off the cope.

Stock required: $4\frac{3}{4} \times 4\frac{3}{4} \times 4\frac{1}{2}$ inches Body
$\frac{15}{16} \times 4\frac{1}{4} \times 4\frac{1}{4}$ inches Loose ring

ORDER OF OPERATIONS

1. Prepare and mount the material for the loose ring upon a screw plate. True up the face; then scribe upon this surface a circumference that is the diameter of the inside of the rim.

FIG. 323.—The templet used in testing the inside surface of the loose ring.

2. Turn out a hole of the same dimension to a depth of $\frac{3}{4}$ inch. Allow stock to remain about the screw at the center.

3. Make a templet as shown in Fig. 323, and with its aid turn to shape the convex surface of the rim as indicated by *C* (Fig. 324).

4. Scribe upon the convex surface a circumference whose radius is *D* of the layout. With the aid of a bevel, turn the

conical-shaped parting surface. Figure 324 shows the loose ring at the completion of this operation.

To give the maximum strength to the arms, the grain of the wood must be in the direction of the axis of the pattern.

5. Prepare the material for the body of the pattern, and mount it upon a face plate.

6. Turn to the greatest diameter of the pattern and true up the face of the material. Scribe upon the face a circumference whose radius is *E* of the layout.

7. Turn out a conical-shaped depression, the dimensions of which are represented by *EFG*.

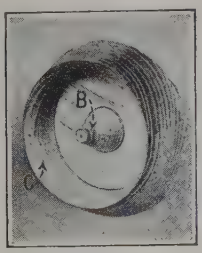


FIG. 324.—The loose ring at the completion of the first turning operation.

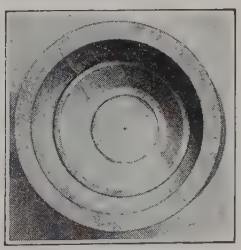


FIG. 325.—The body of the pattern at the completion of the first turning operation and ready to receive the loose ring.

8. Scribe upon the bottom surface of the depression the circumference of the hub; then turn this surface of the pattern to shape.

9. Lay off the distance represented by *H*, and proceed to turn to shape the parting surface. The loose ring is to be used to test the surface as the turning progresses. Colored chalk applied to the parting surface of the loose ring will aid the testing operation. The work at this stage of completion is shown in Fig. 325.

10. Secure the loose ring within the body of the pattern by three brads driven from the outer diameter of the work. Allow the heads of the brads to protrude so that they may be withdrawn.

11. Turn the face of the loose ring flush with the face of the body of the pattern. Then, with the aid of templet shown in Fig. 323, complete the inside shape of the rim.

The brads are now withdrawn and brads driven from the inside of the rim and the exterior form of the pattern turned.

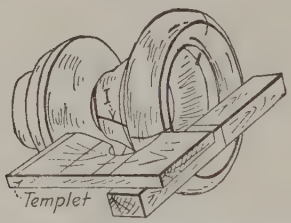


FIG. 326.—Type of templet used in turning the exterior form of the pattern.

Illustrated in Fig. 326 is the arrangement of the templet used for this operation. The templet is also used to guide the scriber when scribing the center lines *I* of the arms.

12. Space and scribe the center lines *I* of the arms; then lay out their shape.

Remove the waste between the arms by boring a series of $\frac{3}{16}$-inch holes tangent to each other.

Separate the loose ring into two parts with a backsaw.

Reminder

What may be a quick action job for the patternmaker may prove to be a slow process job for the molder.

PATTERN 47

THREE-LEGGED BASE

Features presented:

✓Spider construction

Rechucking strips or blocks

Scribing lines with dividers upon a surface when the center of rotation is not in the same plane

Figure 327 is the drawing of a cast-iron three-legged base.

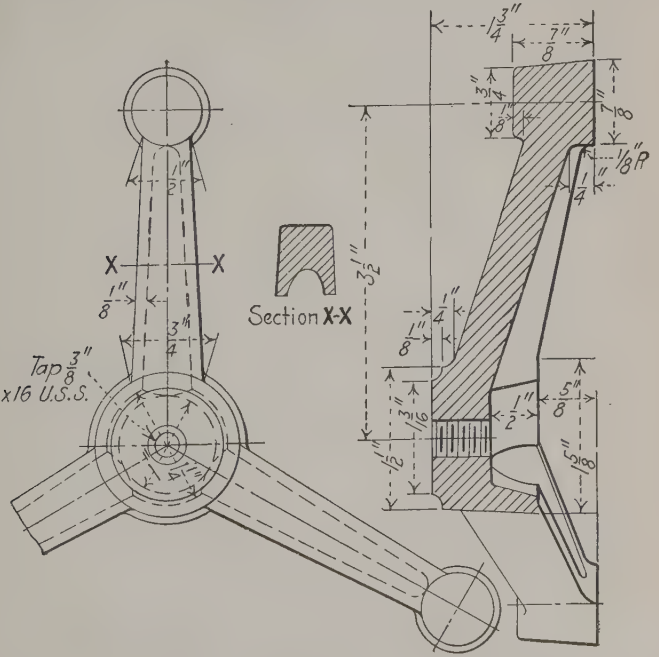


Fig. 327.

The casting consists of a hub from which radiate three legs. Pads upon the end of the legs support the casting.

When a number of members of a casting radiate from a center, as in the case of the three-legged base, it is commonly called a *spider*. *Spider construction* is the term commonly applied to this arrangement of material.

When the pattern is comparatively small and the members are of an even number, the material is usually lapped together. If the members are of an odd number, as that of the base, the material is joined together by other means.

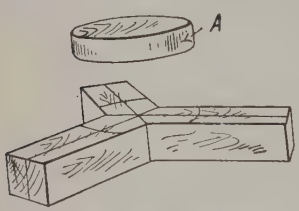


FIG. 328.—The material for the base pattern in process of gluing together.

For the base pattern, three pieces of material are joined together as shown in Fig. 328. Glue applied to the end grain of the wood cannot be relied upon to hold the material together; therefore the joints are further secured by the disk-shaped piece *A*, shown above the surface to which it is attached.

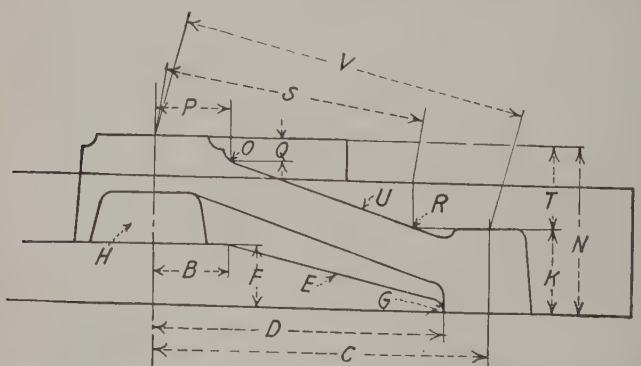


FIG. 329.—The layout of the base pattern. It also shows how to obtain the radius for scribing the various arcs.

A partial layout of the pattern, as shown in Fig. 329, is required. It is used as a reference from which location of points and dimensions are taken and applied to the work.

The length of the three pieces of material should be about 5 inches. This length permits the work to be secured to the

face plate for the second turning operation with screws. The screws are inserted through the face plate and enter the material beyond the limits of the pattern.

Stock required: $1\frac{3}{8} \times 1\frac{5}{8} \times 15\frac{1}{2}$ inches
$\frac{3}{4} \times 4 \times 4$ inches

ORDER OF OPERATIONS

1. Prepare (dress to $1\frac{1}{4}$-inch thickness) and arrange the joints, and glue the parts together. Pinch dogs are best for holding the parts together while the glue is drying. When the glue has set, attach the disk-shaped piece *A*.

The depressed surfaces of the pattern are turned first.

2. Mount the work upon a face plate, and true up the face.

3. Scribe a circumference, the radius of which is *B* of the layout. Scribe upon the interrupted surface circumferences whose radii are *C* and *D*.

Caution: Be careful that the tool does not catch when turning or when scribing a line upon an interrupted surface.

Keep the tool rest close up to the surfaces being turned.

Remove the waste material by a series of light cuts.

4. Establish the slope of surface *E* by turning a depression whose radius is represented by *B* and depth by *F*, and a semicircular groove of $\frac{1}{8}$ inch radius, as at *G*.

5. Turn interrupted surface *E*; then space and scribe the radial center lines of the legs.

Refer to the instruction pertaining to the scribing of lines upon irregular surfaces (pages 230 and 232).

6. Turn out the depression indicated by *H*, and sandpaper its surfaces.

Caution: Do not sandpaper the interrupted surface.

7. Lay out upon the surfaces *E* the outline of the legs, and then dress out the depression as required by the cross section of the leg *XX* (Fig. 327).

8. Remove work from the face plate, and scribe the position of the radial center lines upon the ends of the material as at *I* (Fig. 330). Scribe upon the edge surfaces of material as at *J* the location of the center line of the pads. Gage lines upon

the ends of the material, using the dimension represented by *K* of the layout. The illustration shows the work rechucked and ready for the turning operation.

9. To rechuck the work, true up the surface of the facing material of the face plate; then scribe a circumference, the radius of which is $\frac{1}{8}$ inch greater than the radius *D*.

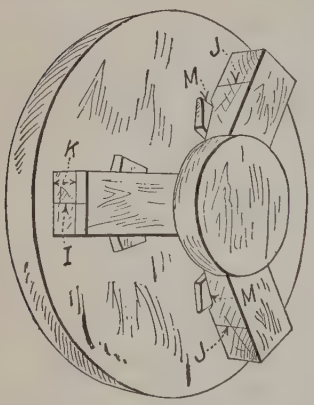


FIG. 330.—The work rechucked.

10. Divide the circumference into three equal parts. With glue, attach at these points pieces of about $\frac{1}{4}$-inch thickness, 3 inches long. The outer edges of the pieces are sawed to conform to the circumference.

11. Turn off the face and edge of the strips until they conform to the surface of the legs as at *M*. Each leg of the material is to be secured to the chuck as described.

12. Reduce the material to the dimension represented by *N*.

13. Establish the point *O* by turning a cylinder whose radius is equal to *P* and length to *Q*.

14. Establish the point *R* by turning the interrupted surface, using the dimensions *S* and *T*. A line drawn through these points will represent the slope of the surface *U*.

15. Turn this face of the work to shape.

16. Scribe arcs upon the interrupted surface, using the dimension *V* as a radius.

17. Detach from the chuck, then proceed to transfer to this face of the material the radial center line of the legs.

18. Complete the laying out of the pattern, and dress the work to required shape.

PATTERN 48

TILLER WHEEL

Features presented:

Construction

Mounting material for turning

Application of a jig

Figure 331 is the drawing of a brass tiller wheel.

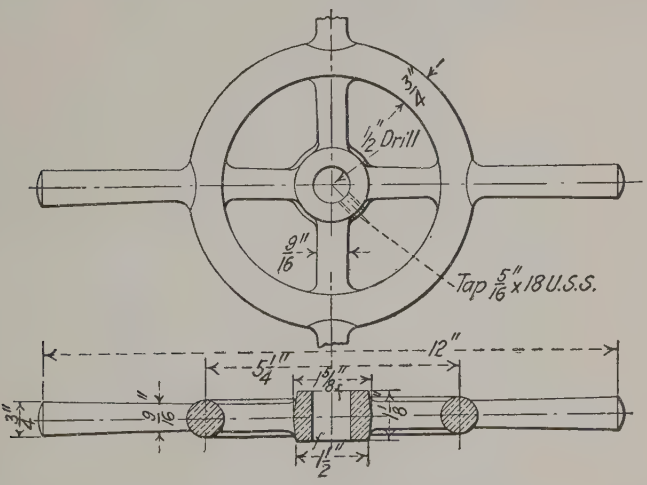


FIG. 331.

Attached to a face plate, as shown in Fig. 332, is the material from which one of the halves of the ring that supports the spokes is turned. The small area of the cross section of the rings makes it advisable to avoid the use of metal fasteners. Therefore, the material is affixed to the face plate by four strips of paper. The ends of the paper are shown protruding from the joint at *D*. Glue the paper to the face plate, and then glue the material to the paper.

The insertion of the edge of a chisel at the points of adhesion will cause the paper to split and release the work. To relieve the paper of undue strain, the encircled waste material is further secured by two screws as at *E*.

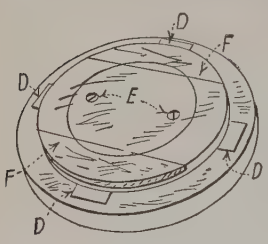


FIG. 332.—The material for one of the halves of the ring mounted upon a face plate.

To give added strength to the ring at the points where the semicircular grooves for the spokes are formed in the direction of the grain of the wood, the material is rabbeted out and the strips, as at *F*, with the grain of the wood lying in a transverse direction glued in.

Stock required:	$\frac{1}{2} \times 6\frac{1}{2} \times 13\frac{1}{2}$	inches	Rings
	$\frac{5}{16} \times 1\frac{1}{2} \times 27$	inches	Strips
	$1\frac{3}{8} \times 2 \times 13\frac{1}{2}$	inches	Spokes
	$1 \times 1 \times 13$	inches	Spokes

ORDER OF OPERATIONS

1. Dress the material for the two halves of the supporting ring to rectangular shape, saw the rabbets, and glue strips *F* in place.

2. Dress the material from which the double spoke *A* (Fig. 333) is to be turned, to the required thickness of the hub of the wheel. Dress the material to a parallel width of about $1\frac{3}{4}$ inches.

3. Scribe the center lines about the material, and scribe upon each face a circumference that is the diameter of the hub. Saw the material to the shape shown.

4. Mount and turn the material to the greatest diameter of the spokes. Lay off from the center of the hub the length of the cylindrical portion and the tapered portion of the spokes. Turn the spoke that is toward the dead center to shape and then the spoke that is toward the live center. This order of turning gives the maximum resistance to vibration. This member at the completion of the turning will appear as shown at *B* (Fig. 333).

One of the two other spokes that are turned separately is shown at *C*. The ¼-inch dowel *G* is the means of securing the spokes to the hub.

5. Prepare the material for the two halves of the supporting ring (dress to required thickness), and attach to a face plate

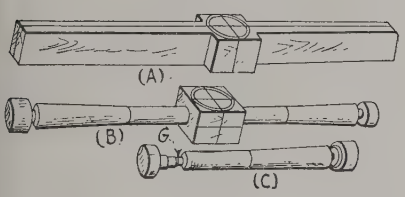


FIG. 333.—The spokes for the pattern in process of shaping.

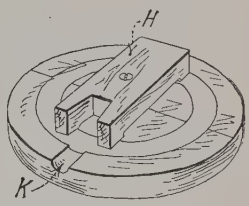


FIG. 334.—Jig used for holding the rings while dressing out the grooves for the spokes.

as instructed. The use of two face plates will expedite the work.

6. Scribe upon the face of the material circumferences at the inside and the outside of the ring. Separate the ring from the enclosed waste with a spear point or skew chisel. Turn the ring to shape. A templet as shown in Fig. 268 (page 231) is to be used to test the convex surface.

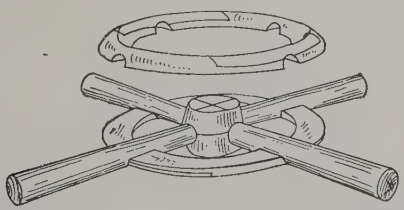


FIG. 335.—The members of the tiller-wheel pattern shaped and ready to be glued together.

Figure 334 illustrates how a jig is made by turning a groove in the face plate that receives and holds the rings while dressing out the semicircular grooves for the spokes. The block *H*, which is attached with a screw, acts as a clamp and holds the ring in the groove.

A groove is dressed out as at *K* to conform to the shape of the spoke. It is used as a guide in directing the gouge in cutting to shape the grooves in the rings.

To give the maximum strength to the construction, the grain of the wood in the two rings should be placed in a transverse direction.

Figure 335 shows how the members of the pattern will appear when shaped and ready to be glued together.

Assemble the members, and inspect the joints. Mark the position of the parts that there may be no delay during the gluing-up operation.

Blocks placed between the hardwood jaws of the hand screws and the rings during the gluing-up operation will prevent the defacement of the surface of the pattern.

QUESTIONS

1. What feature made possible the molding of the small handwheel, pattern 46?

2. Why were templets used in turning the small handwheel pattern?

3. What is understood by the term *spider construction?*

4. Why was a layout necessary for the turning of the three-legged base pattern?

5. When it is desired to avoid metal fasteners, how may the material for small work be attached to the face plate?

6. What is understood by a jig, as applied to patternwork?

7. Why should extreme care be taken in turning an interrupted or intermitting surface?

8. For what purpose was a jig used in making the tiller-wheel pattern?

9. In turning the spokes of the tiller wheel, why is it advisable to begin the turning at the dead-center end of the work?

PATTERN 49

CHAMBER

Features presented:

Coring holes in pipe-connection castings
Joining material of a semicylindrical cross section
Application of a jig
Supporting work upon saw table
Combination core box

Figure 336 is the drawing of a brass chamber.

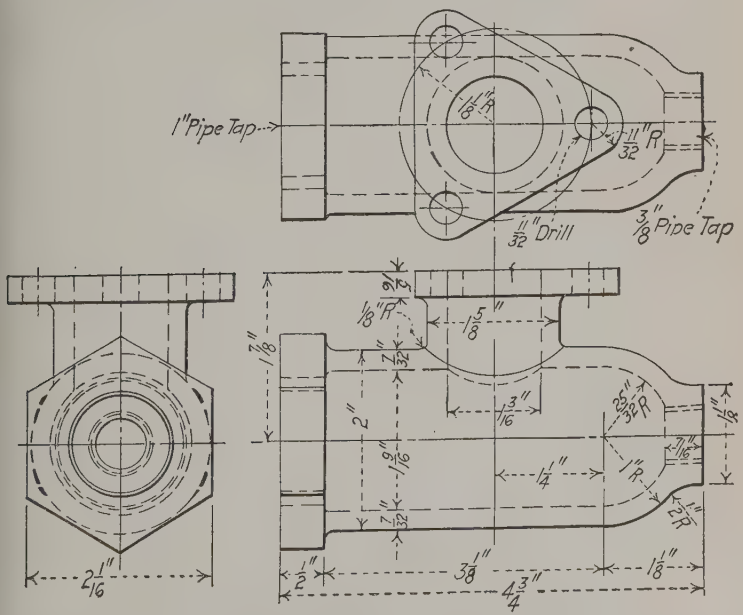


Fig. 336.

The drawing specifies that an opening in one end of the casting is to be tapped to receive a 1-inch diameter pipe. A hole

in the other end of the casting is to be tapped to receive a $\frac{3}{8}$-inch pipe.

The approximate outside diameter of a 1-inch standard pipe is $1\frac{5}{16}$ inches (1.31 inches). The approximate outside diameter of a $\frac{3}{8}$-inch standard pipe is $\frac{43}{64}$ inch (0.675).

The usual practice (unless otherwise instructed) in the case of cored holes that are to be tapped to receive a pipe is to make the diameter of the core the size of the pipe specified. A cored hole of this dimension will give sufficient finish allowance for the enlarging and tapping operation.

Figure 337 illustrates the shape of the joint made between the branch and the body of the pattern. This shape of joint is used when the diameters of the members are equal or approx-

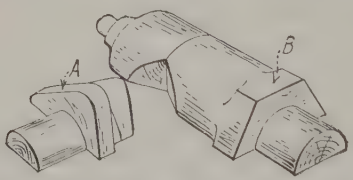


FIG. 337.—The parts of the drag half of the chamber pattern ready to be attached together.

imately equal. When the diameters are equal, the angle of the joint surfaces will be a right angle, and the junction of the cylindrical surfaces will miter.

If there is a slight difference in the diameters, as in the case of the two members of the chamber pattern, the angle of the joint surfaces will be greater than 90 degrees, and the cylindrical surface will not miter. This slight difference will be corrected by the fillet affixed along the line of intersection.

The flange *A* of the branch and the hexagonal wrench-grip portion *B* of the body are to be turned to a circular form that will equal their dimensions across the corners, then laid out and dressed to shape.

Figure 338 shows the shape of the joint between the parts laid out upon the parting of the drag half of the body. The distance *C* that the branch enters the body of the pattern is

obtained by making a cross-section layout along the center line of the branch.

Note how strips as at *D* are bradded to the ends of the core prints to cause the parting surface to lie parallel to the table

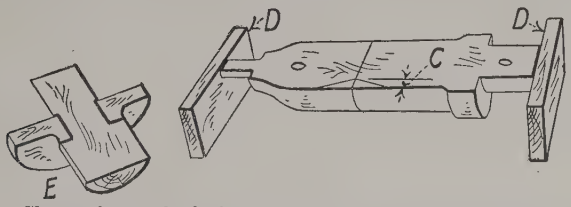


FIG. 338.—Shows the method of supporting the body of the pattern while the joint surface that is to receive the branch is being sawed to shape.

while the outline of the joints is being sawed. The branch as it will appear at the completion of turning is shown at *E*.

CORE BOX FOR THE CHAMBER PATTERN

The parts that make up the core box for the chamber casting are shown in Fig. 339.

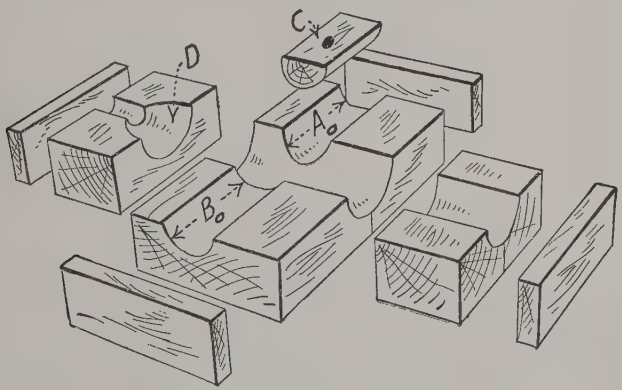


FIG 339.—The parts of the core box for chamber shaped and ready to be attached together.

To make right and left half cores that are subsequently pasted together, the branch cavity is formed to the right and to the left of the center line of the box as at *A* and *B*. Above the cavity *A* is shown the stop-off piece *C*. The stop-off piece con-

forms to the shape of the cavities and is the means of closing them. One-half of the core is made with the stop-off piece placed in cavity *A*. The other half of the core is made with the stop-off piece placed in cavity *B*. The spherical surface of the core cavity *D* is turned.

When the difference between the diameters of the body of a pattern and of a branch will not permit of the making of the joint by the method described, the joint is then sawed to shape by attaching the branch material, as at *G*, within a jig, as shown in Fig. 340.

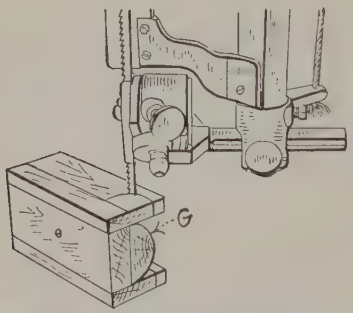


FIG. 340.—Sawing by the aid of a jig the shape of a joint surface.

The outline of the joint surface to be sawed is scribed upon the top surface of the jig.

QUESTIONS

1. How was the maximum strength of construction obtained from the wood for the three-legged base pattern?

2. What means were taken to reinforce the abutting end joints of the material for the three-legged base pattern?

3. What made it possible to use a miter joint in joining together the body and branch members of the chamber pattern?

4. How was the body of the chamber pattern supported while the joint was sawed to receive the branch member?

5. What is to be understood by the expression, *combination core box?*

6. What is the general practice applied to the diameter of a cored hole that is to be tapped to receive a pipe?

7. How was part of the core box for the chamber pattern stopped off?

PATTERN 50

ELBOW WITH SIDE OUTLET

Features presented:

- Construction
- Loose-flange application
- The slab core
- Locating a core without a core-print depression
- Application of dowel pins
- Application of a jig

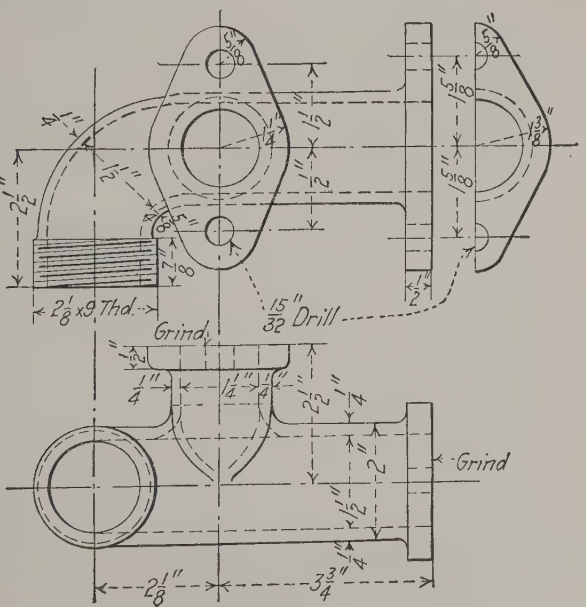


FIG. 341.

Figure 341 is the drawing of a cast-iron elbow with side outlet.

A study of the distinctive shapes that go to make up a casting, a layout of the pattern, and a fair knowledge of what can be done on the machines reduce the benchwork to the minimum. This feature is illustrated by the pattern for the elbow, since it may be made practically upon the lathe, the band saw, and the sander.

The drag part of the pattern is shown in Fig. 342. The flange *C* is shown directly above the position it occupies upon the part *B*. The flange is made loose. When the ramming of the sand has reached the height of the face of the flange, it is struck off level with this surface. The flange is then drawn

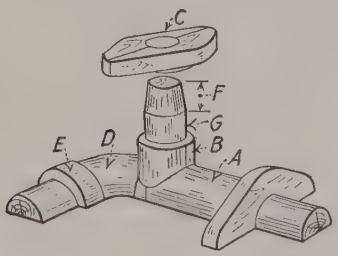


FIG. 342.—The drag part of the elbow pattern.

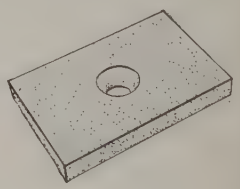


FIG. 343.—The slab core used to cover the depression left vacant by the flange *C*.

out and its depression covered by a slab core, as shown in Fig. 343. The slab core is located and held in place by the hole through the core that engages the core print of the pattern. The mold is then carried to completion in the usual way.

Make the slab core about $\frac{3}{4}$ inch in thickness and $1\frac{1}{2}$ inches greater in width and in length than these dimensions of the flange.

The adjacent parts of the body of the pattern may be secured together with glue and brads or by turning dowels upon part *A* and part *E* and inserting the dowels into the bend portion *D* of the pattern.

The flange *C* is located upon part *B* by being received upon the neck *G*. The diameter of the neck is equal to the diameter of the core print *F*. The position of the flange is registered by a small dowel pin.

When the dimension of a surface will not permit the use of a stock dowel pin, a heavy brad may be used. In the present

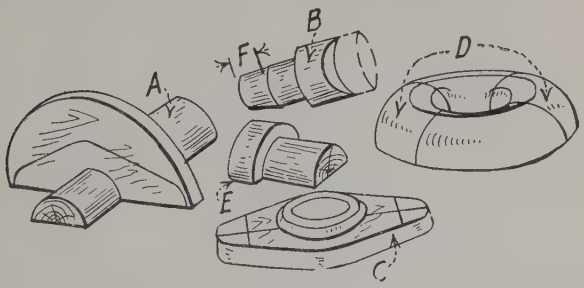


FIG. 344.—The component parts of the drag half of the pattern for elbow.

case the width of the shoulder upon which the flange rests will not permit of the use of a stock dowel; therefore a brad is to be used.

Use the brad as a drill point, and bore a hole through the flange into the shoulder. Drive the brad through the flange. Cut off the brad about $\frac{3}{16}$ inch from the surface of the flange with a pair of nippers; then point it slightly with a file.

Figure 344 shows the component parts of the drag half of the pattern. Parts *A* and *E* need no explanation.

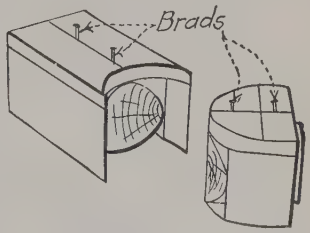


FIG. 345.—The jig used in sawing to shape the joint surface of part *B*.

Turn part *B* to the required diameters. It should be of ample length, as indicated by the dotted lines, to permit of its being sawed to fit the convex surface of part *A*, as shown in Fig. 342. The sawing operation is accomplished by securing part *B* within a jig, as shown in Fig. 345. An arc that represents the outline of the surface to be sawed is scribed upon the top surface of the jig and the combination separated, as shown.

The material for flange *C* is sawed in the form of a disk. It is mounted upon a face plate and the fillet and the hole at the

center turned. Its shape is then laid out and the work sawed and sanded to this outline.

The bend part *D* (Fig. 344) is made by turning a ring whose radii are that of the radii of the bend. The ring is then divided into four equal parts, as shown, and two 90-degree segments cut from it. The grain of the wood of the two segments to be used is to lie in the direction of their greatest chord.

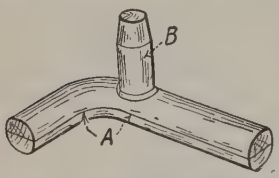


FIG. 346.—The core used to supplement the pattern in forming the mold.

Verify the shape and the dimensions of the parts by assembling one-half of the pattern upon the layout.

Allow glue to set; then use this half in the assembling of the opposite half. Reinforce the joints with brads and corrugated fasteners.

CORE BOX FOR THE ELBOW PATTERN

Figure 346 illustrates the core that forms the interior surface of the elbow casting. It is made in two halves, the two halves being pasted together along the line *A*.

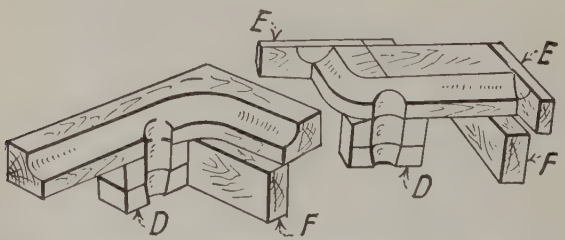


FIG. 347.—The core box which forms the drag or outlet portion of the core.

The core box that forms one-half of the body core and the outlet portion *B* is shown in Fig. 347. This half of the core can be made without parting the box as shown. However, this feature facilitates the core work, since it makes possible the removal of the box from the core with the least disturbance to the sand.

Figure 348 illustrates the core box at one stage in its making. The parting has been made (sawed) and the outline of the core cavity laid out. The saw cut will cause a variation to occur on the convex surface of the parting and also upon the edge and upon the end of the material. This is to be corrected and the block *C* attached before proceeding with the laying out of the cavity.

The core-print portion *D* (Fig. 347) of the box is made independent of the box and then attached. The ends of the core cavity are closed by the pieces *E*. The cleats *F* support the box in a level position.

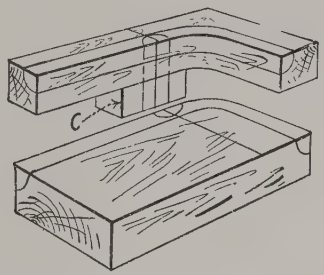


FIG. 348.—The core box in process of making.

The instruction given with the core boxes for pattern 42 (page 259) also applies to the core box (not shown) but required for the cope half of the core.

QUESTIONS

1. What were the special pattern and molding features presented by the elbow with side outlet?
2. What is to be understood by the expression *slab core?*
3. How is a slab core used in connection with the elbow pattern? How is it located in place?
4. How was the loose-flange member of elbow located and held in place upon the body of the pattern?
5. For what purpose was a jig used in the forming of the elbow pattern?
6. How was the bend portion of the elbow pattern shaped?

PATTERN 51

HOSE CONNECTION

Features presented:
√ An irregular parting surface
√Bedding in a pattern
Core-print arrangement
√Bedding a core for drying
Figure 349 is the drawing of a cast-iron hose connection.

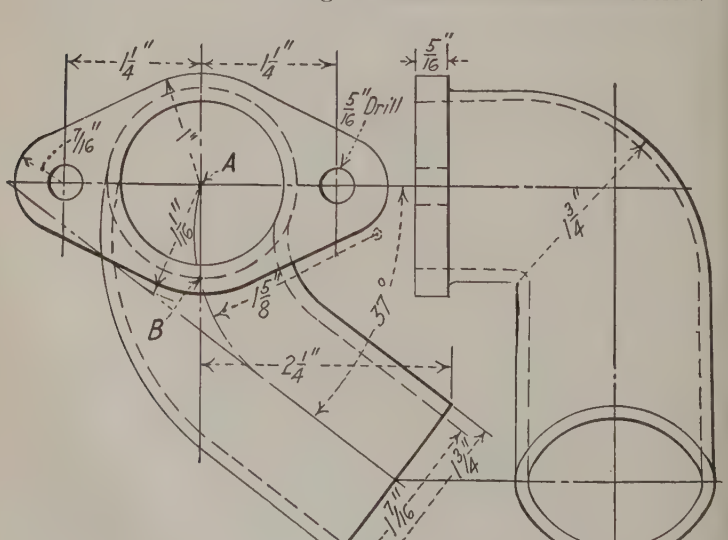


FIG. 349.

The parted patterns heretofore discussed have had a straight parting surface. An irregular parting surface is presented by the pattern (Fig. 350) for the hose connection.

The shape of the parting is made to conform to the center line of the casting with this exception: instead of the parting surface following the arc of the 1⅝-inch radius until it reaches the intersection of the center lines at *A* (Fig. 349), the curved surface of the parting stops at the point *B* where the arc intersects the circumference of the pattern.

Terminating the curved surface of the parting at the point *B* and making the surface from there on straight simplifies the making of the flanged end of the pattern.

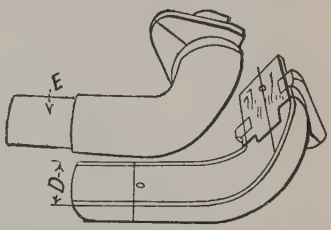


FIG. 350.—Arrangement of the pattern for the hose connection.

Patterns of this character are usually bedded in. This molding operation consists of filling the drag flask with sand and forcing the pattern down to the desired position. The sand is then firmly tucked and rammed about the pattern and the parting made, as shown in Fig. 351.

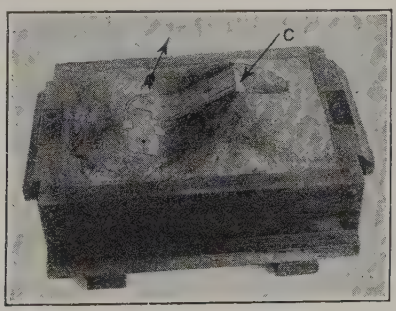


FIG. 351.—The drag part of the mold for the connection showing the pattern in the sand.

An arrow indicates the direction in which the pattern is drawn from the sand. In order to do this, the parting is arranged as at *C*, and the impression of the end of the core print is taken by the sand of the cope.

Drawing the pattern in this direction requires that the diameter of the core print of the drag half of the pattern be

made equal to the diameter of the pattern shown at *D* (Fig. 350).

The core print of the cope part of the pattern, as at *E*, is dressed to the shape shown. If the cope half of the core print of the pattern were made to correspond to that of the drag half, it would be necessary to form a shoulder in both halves of the cavity of the core box. This shoulder would interfere with the removal of the cope half of the box from the core.

Figure 352 illustrates the pattern in course of making. The parting has been arranged, the dowel *F* set, and the cylindrical portion of the body of the pattern turned.

Bore the holes for the dowel pins in the direction in which the pattern separates with the mold (Fig. 351).

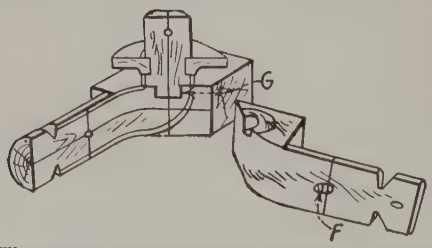


FIG. 352.— The pattern for the hose connection in process of making.

To turn, secure the parted end of the material together in the usual way. Secure the parting surfaces together beyond the bend with pinch dogs.

A dowel joint is used, as at *G*, to secure the flange portion of the pattern to the body.

Trace from a paper templet the outline of the bend upon the parting surface.

On account of the position of the core in the mold and its points of support, the core print at the flanged end of the pattern is to be made $\frac{3}{4}$ inch greater in length than that prescribed by the table of core-print proportions.

CORE BOX FOR THE HOSE-CONNECTION PATTERN

There would be no advantage in the forming or in the drying of the core for the hose connection if it were made in halves,

then pasted together. Therefore, the box is made as shown in course of construction (Fig. 353). The parting has been arranged and the outline of the core cavity laid out.

The arrows indicate the direction the box separates. The dowel pins are to be set in the same direction.

Verify the shape of the parting of the core box with the parting surface of the pattern.

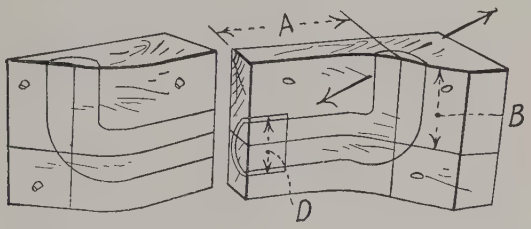


FIG. 353.—The hose-connection core box in process of making.

Transfer from the pattern the distances *A* and *B*. Transfer to this surface of the core box, by the aid of a paper templet, the outline of the core made upon the parting surface of the bend of the pattern.

The enlargement at the end of one-half of the core cavity at *D* is made to correspond to the core-print portion *D* of the drag half of the pattern (Fig. 350).

Bedding a Core.—Because of the form of the core it cannot be laid directly upon a core plate, but must rest upon a bed of green sand while being dried. The bed is prepared by removing one-half of the core box and setting a frame over the work. Sand is then packed over the core and the box and struck off level with the frame. A core plate placed upon the frame permits the work to be rolled over and the box and frame removed.

PATTERN 52

RING

Features presented:

Segmental construction

Figure 354 is the drawing of a cast-iron ring.

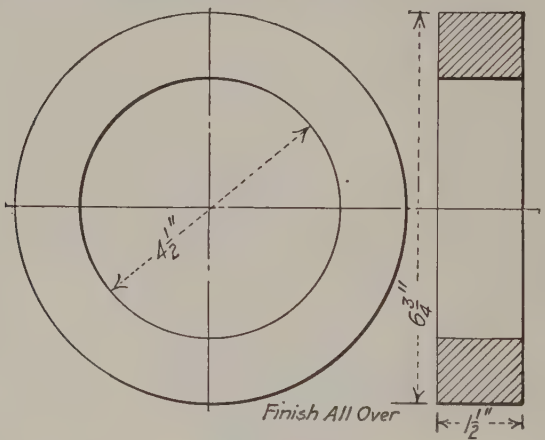


Fig. 354.

Ring patterns made of one piece of wood cannot be relied upon to retain their form; therefore they are built up by what is termed *segmental construction.*

Segmental construction consists in laying upon one another a series of rings or courses, each course consisting of a number of parts called *segments.*

The grain of the wood in the segments lies in the direction of the greatest chord of the segment and thereby gives the maximum length grain wood around each course. The strength of a pattern built up by this construction is proportional to the number of courses and the number of segments to a course.

Courses for patterns up to 14 inches in diameter may consist of four segments, but from 14 to 36 inches in diameter it is the common practice to use six.

The accompanying table of chords dividing a circle into from 3 to 24 equal parts will be found very useful when applied to segmental and stave construction.

The quantities in the columns headed *A* are the number of segments or staves required to a circle.

To obtain the length of a chord, multiply the diameter of the circle upon which the chord is to be laid off by the quantity found in columns *B* opposite the number of segments required.

TABLE OF CHORDS OF SEGMENTS

A	*B*	*A*	*B*	*A*	*B*	*A*	*B*
		7	0.4338	13	0.2393	19	0.1646
		8	0.3826	14	0.2225	20	0.1564
3	0.8660	9	0.3420	15	0.2079	21	0.1490
4	0.7071	10	0.3090	16	0.1950	22	0.1423
5	0.5877	11	0.2817	17	0.1837	23	0.1361
6	0.5000	12	0.2588	18	0.1736	24	0.1305

It is often more convenient to lay segments upon a face plate, then face the joint in the lathe. However, this procedure is not necessary, since the joints between courses may be planed. Add about $\frac{1}{16}$ inch to the thickness of segments when the joint between courses is to be turned.

Whenever the cross section of a member will permit, it is a good practice not to depend entirely upon the glue, but to nail the segments as well. Nailing hastens the work, since it eliminates clamps and the delay of waiting for the glue to dry.

To obtain the maximum strength, the joints between the ends of the segments are placed midway between those of the preceding course.

Build up the work perpendicular to the surface upon which it is laid.

Do not fit a course of segments together and then proceed to lay them, but rather fit and glue each segment in sequence.

Make a layout of the cross section of the pattern as shown in Fig. 355; then scribe lines to represent the thickness and the width of the segments. The thickness of the courses is to be equally proportioned. The ring pattern will be built up of

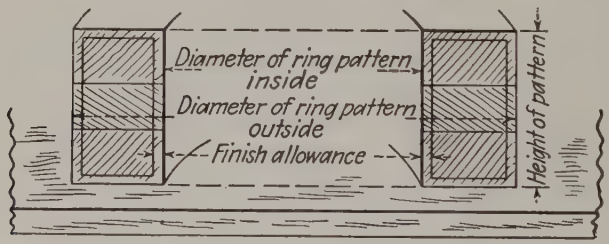


FIG. 355.—The layout of the ring pattern.

three courses. The courses will be made up of four segments. It would be a waste of time to lay out the shape of each segment; therefore one segment is laid out and sawed to shape. It is used as a templet to trace the outline of the other segments upon the material as shown in Fig. 356.

Allow for the turning operation $\frac{1}{4}$ inch of waste material upon the inside and the outside edges of the segments. Upon

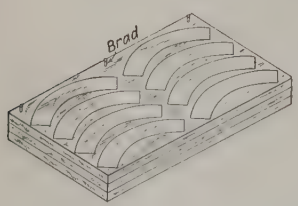


FIG. 356.—Multiple sawing of segments.

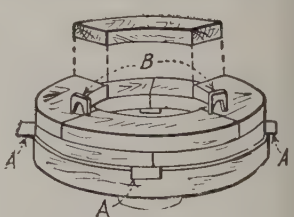


FIG. 357.—Segments in process of laying.

the ends of the segments, allow at least $\frac{1}{16}$ inch for fitting them together.

Figure 357 shows the laying of segments upon a face plate.

The segment that completes the second course is shown directly above the surfaces to which it is glued.

To prevent the segments being affixed to the wood facing of the face plate by the glue forced out of the joints, strips of paper, as at *A*, are glued to the facing at these points.

ORDER OF OPERATIONS

1. Scribe a circumference that is the outside diameter of the layout of the work. Dress both ends of a segment (use trimmer or sander); then set its outer edge to coincide with the circumference scribed. Secure the segment to the plate with two brads.

2. Fit the abutting end of the next segment into place and dress the opposite end. Apply glue to the abutting ends, and drive in a pinch dog as at *B*. Secure this segment to the plate with brads. Proceed in a like manner to attach the next segment.

3. Place the last segment of the course above its location, and transfer to its undersurface with a scriber the length of the opening it is to fill. Dress the segment to this length, and secure it in place.

4. True up the face of the course of segments; then proceed to lay and glue on the next course. Verify the height of each course with the layout.

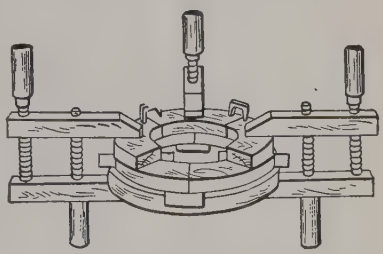


FIG. 358.—Segments clamped together with hand screws while the glue is drying.

5. Turn the pattern to size, and finish in the usual way.

To detach the pattern, insert edge of chisel between plate and work, and carefully pry apart.

If the brads are found to remain in the work, they may be pulled out with pincers or cut off with a pair of nippers and driven back with a nail set.

When the cross section of a member will not permit the use of brads, hand screws are used, as shown in Fig. 358, to clamp the segments together while the glue is setting. The glue will take about 30 minutes to set.

PATTERN 53

HOUSING

Features presented:

Three-part mold

Application of templet

Segmental construction

Figure 359 is the drawing of a cast-iron housing.

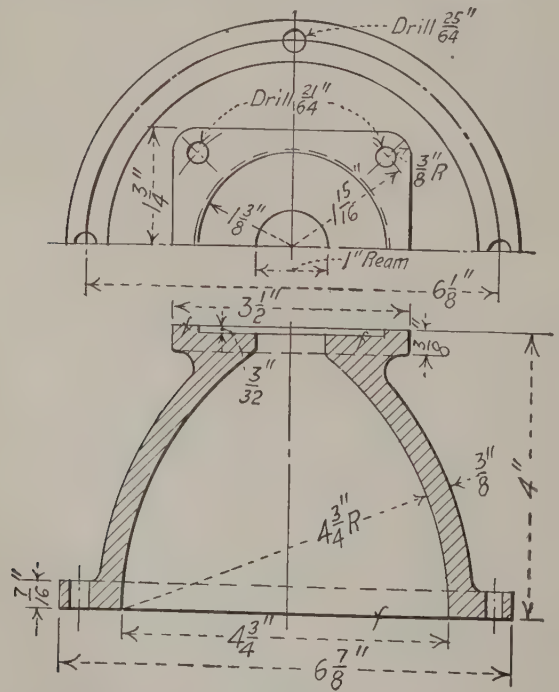


FIG. 359.

If segments of the same radius were used in building up some patterns, it would cause an excessive waste of material.

The selection of the housing pattern is to present a method that makes possible the saving of this material.

When a pattern is built up of courses of varying diameter, as in this case, the course of segments of the greatest diameter is laid first. This order of procedure gives a better support to the work and facilitates the clamping together of the segments. Because of the shape and the thinness of the wall of the pattern, brads are not to be used.

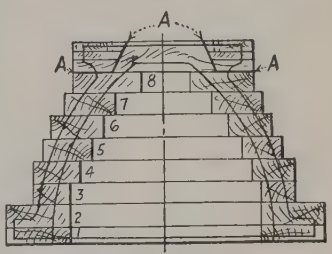


FIG. 360.—The layout of the housing pattern showing its constructional features.

The layout required of the pattern is shown in Fig. 360. It shows the number of courses and how the diameter of the course varies with the section of the pattern. The square flange is made loose; the parting line is indicated by *A*.

Verify with the layout the distance at which the joint between each course of segments occurs above the surface of the face plate. A disk equal in diameter to the last course of segments closes the top and completes the building-up operation.

Loose Flange.—Build up the loose flange of three courses of segments. Make the diameter of the courses about ½ inch greater than the distance across the corners of the flange. Turn the parting surface and the thickness of the flange; then dress the flange to rectangular shape.

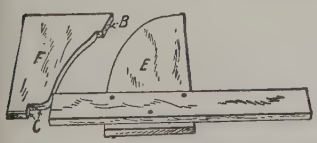


FIG. 361.—The two templets required in turning the pattern.

Turning the Body of the Pattern.—True up the face of the work; then detach it, and remount it in the reverse position. Turn the face of the flange. The joint between courses 1 and 2 should occur at about the center of the thickness of the flange.

Turn the interior surface. The circumference of the inside diameter of the pattern scribed upon the face of the flange

locates the position of the templet *E* shown in Fig. 361. The crossbar of the tool rest is to project into the work so that it will give support to the tool near the cutting edge.

Rechuck the work, and turn the flange to the required diameter and thickness. Turn the work to the over-all height of the pattern. Turn the parting surface *A* to fit the parting surface of the loose flange.

Turn the exterior shape of the pattern. The templet *F*, shown in Fig. 361, is used to test this surface. The templet is located by the surface *B* being brought into contact with the parting surface that receives the loose flange and the

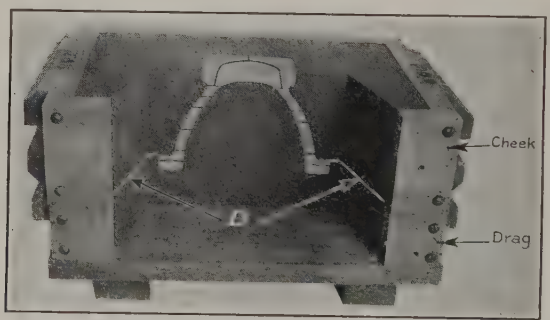


FIG. 362. —Sectional view of the drag and cheek parts of the housing mold showing the pattern in the sand.

respective surfaces *C* of the templet into contact with the flange of the body of the pattern.

Molding the Pattern.—A three-part mold is used to take the impression of the housing pattern. As the name implies, a three-part mold is made up of three sections, namely, a cope, a drag, and a section that lies between the cope and the drag, called a *cheek*. A cross section of the mold illustrated in Fig. 362 shows the pattern embedded in the sand of the cheek and the drag. The parting between the cheek and the drag is shown at *D*.

To mold the pattern, ram up a false cheek. This preliminary work is done to facilitate the subsequent ramming up of the permanent cheek. Place the loose-flange end of the pat-

tern upon the molding board, ram up the false cheek and make a temporary parting upon which to ram up the drag.

Ram up the drag. Roll the work over, remove the false cheek, and shake out the sand.

The parting that is to separate the permanent cheek and the drag is now arranged around the edge of the back of the flange as at *D* and the cheek placed in position and rammed up.

Make the parting for the cope; then ram up this section of the mold.

To remove the pattern, lift off the cope, lightly rap the pattern, and draw the loose flange.

The cheek is now lifted off and the pattern lifted from the sand. The housing pattern may also be molded in a two-part flask by using a slab core. In molding the pattern by this method, the large diameter of the pattern is placed upon the molding board and the drag section of the flask rammed up to the height of the face of the loose flange. A flat surface is struck off at this point and the flange taken out of the sand and its impression covered with a slab core. The ramming of the drag is then carried to completion and the work rolled over in the usual way. Special arrangement must be made in ramming up the cope for lifting out of the sand from the interior of the pattern.

QUESTIONS

1. What was to be learned from the hose-connection pattern?

2. Explain the reason for bedding some cores for drying.

3. Why was the drag and cope halves of the hose-connection pattern core print made of different diameters?

4. What is meant by segmental construction?

5. What relation should the grain of the wood bear to the chord of a segment?

6. What relation should the vertical end joints of the segments bear to the horizontal joints of the courses?

7. Explain the idea of the multiple sawing of segments.

8. What means may be used to prevent glue adhesion between the segments and the face plate?

9. Why were segments of various radii used for the housing pattern?

10. Why was it advisable not to use nails in the housing pattern?

11. Describe and give the names of the sections of a three-part mold.

12. What is the purpose of making a false cheek for a mold?

PATTERN 54

FLYWHEEL

Features presented:
Three-part lap
Wheel construction
Mounting material for turning

Figure 363 is the drawing of a cast-iron flywheel.

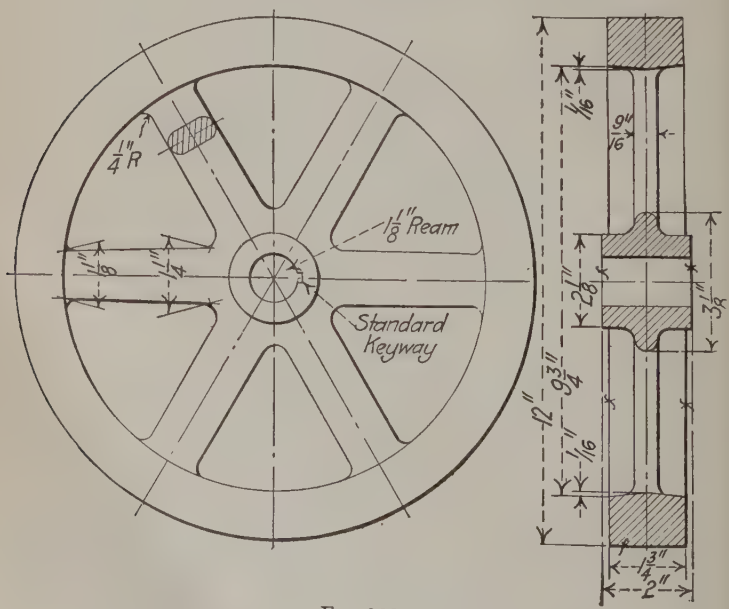


FIG. 363.

The rim of wheel patterns of this type is built up of segmental construction. During the laying of the segments, the arms that have been partially shaped are built in place. This

manner of securing the arms (spider) gives the maximum strength to the pattern.

The hubs are turned separately and located upon the spider with dowel pins. The hub on the cope side of the pattern is parted from the spider. This feature permits the hub to lift off with the cope. The hub on the drag side of the pattern is attached with screws. This manner of attaching the drag hub permits of its being detached.

Make a cross-section layout of the pattern shown in Fig. 364. It is used in determining the thickness and the width of the segment. The dimensions of the pattern are transferred from the layout to the work. Make a layout of one of the

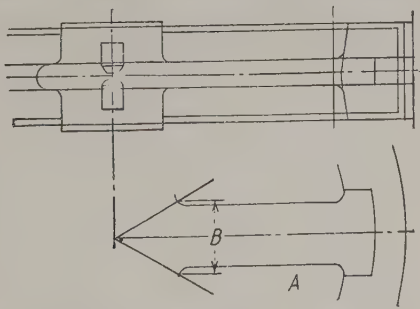


FIG. 364.—The layout required for the flywheel pattern.

arms, as shown at *A*. It is used to obtain the width of the material required for the arms. The width of the material is to be made about ½ inch greater than the distance indicated by *B*.

Allow 1/16 inch in the thickness of the material for dressing the spider to the required thickness.

ORDER OF OPERATIONS

1. Make a three-part lap, as shown in Fig. 365, and glue the material for the arms together; then dress to required thickness.

2. Lay out the shape of the arms, and saw the spider to shape. Allow about ¾-inch thickness of segments beyond the ends of the arms of the spider.

3. Lay the first course of segments. Refer to the information on segmental construction given with pattern 52 (page 296).

4. True up the face of the first course of segments, and lay the second course. This course of segments is not to be glued. The segments are to be attached temporarily with brads located at *C* (Fig. 366).

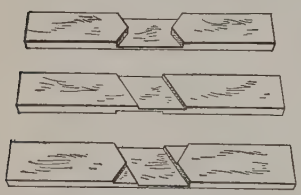


FIG. 365.—The method of lapping together the material for the spider of the flywheel pattern.

5. Scribe upon the face of this course of segments a circumference equal in diameter to the diameter of the spider. Locate the spider upon the face of the segments. The center lines of the arms are to locate about at the joint between the ends of the segments. Trace the outline of the ends of the arms upon the surface of the segments.

6. Detach one of the segments, saw the openings as at *D* in the ends, return it to place, and attach it with glue and brads.

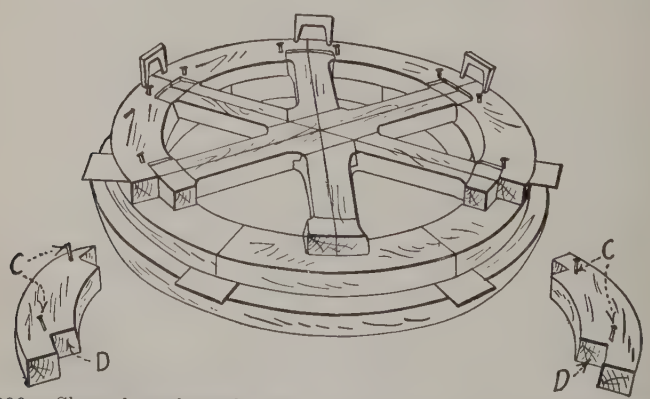


FIG. 366.—Shows how the ends of the arms are secured within the segments.

Removing, then sawing and attaching one segment at a time assure the return of the segments to their former position. This operation in process is illustrated in Fig. 366.

7. Turn off the face of the second course of segments flush with the surface of the spider, and then proceed to lay the next course.

8. True up the face of the work; then turn to the required outside diameter of the pattern. On each side of the center of the thickness of the middle course of segments, lay off one-half the width of the face of the pattern, and scribe lines that represent this dimension.

9. Turn the edge of the rim, then the inside diameter to the face of the arms and forming a fillet at the intersection of these surfaces.

10. Secure three pieces, about ¼ inch thick and 3 inches long, to the face plate with glue and brads, and turn their outer edge to receive the inside diameter of the rim of the pattern.

Attach the work to the face plate with screws, and proceed to turn this side of the pattern.

The surface of the inside of the rim that lies between the arms and therefore cannot be turned is dressed to shape with a gouge.

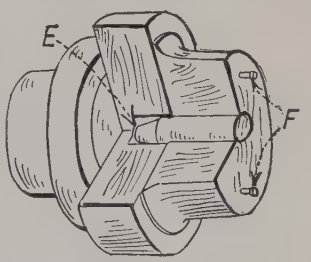


FIG. 367. — Method of mounting the material for the turning of the hubs.

11. Turn hubs to shape. Figure 367 illustrates the method of centering and attaching the material for the hubs to a face plate. A hole is turned in the facing of the plate, as at *E*, to receive the dowel set in the hub material. Dress the material to the required thickness of the hub, and attach with brads located at *F*.

12. Place the hubs in position, and trace the outline of its fillet upon the surface of the spider; then round the edges of the arms to conform to the required cross section shown in Fig. 363.

PATTERN 55

BRAKEWHEEL

Features presented:
Wheel construction
Segmental construction
Rechucking work

Figure 368 is the drawing of a brakewheel casting.

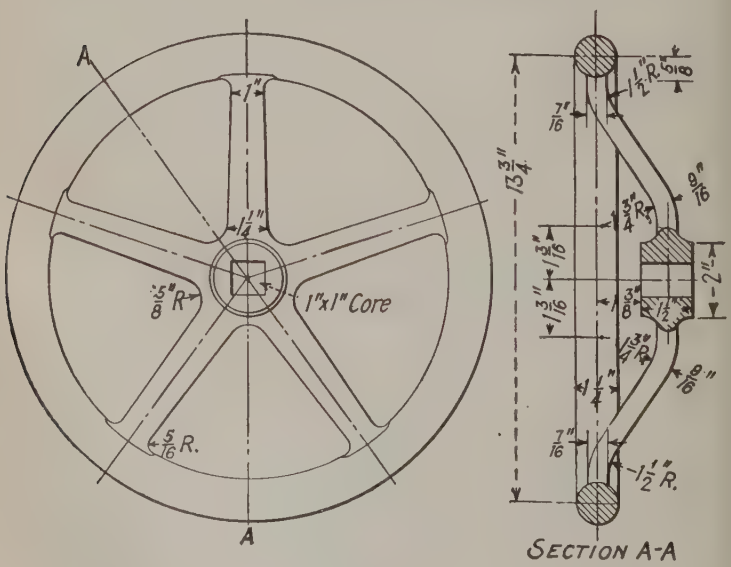


FIG. 368.

In the construction of rims of comparatively small circular cross section, one course of segments is used, their abutting end joints being secured together by a tongue, as at *A* (Fig. 369).

Shaping the segments as at *B* permits the use of hand screws to draw the joint surfaces together during the gluing operation. These projections are then sawed off.

The number of segments is to correspond to the number of arms.

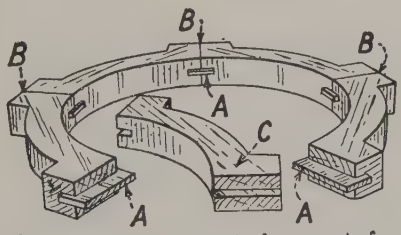


FIG. 369.—The arrangement of segments for rim.

A good practice in gluing together tongue joints of this nature is to glue the segments together in pairs. When the glue has set, the pairs are then glued together. The remaining segment, as at *C*, which will probably require a little fitting, is glued in last.

Following each gluing operation, the segments should be weighted or clamped down upon a flat surface. This will eliminate any distortion of the faces of segments that will often occur.

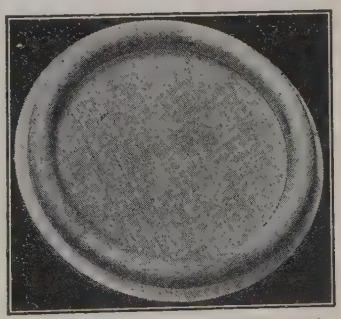


FIG. 370.—Shows the rim at the completion of the first turning operation.

Figure 370 illustrates the work upon the face plate at the completion of turning the semi-circumference of the cross section of the rim.

In performing this operation, the face of the work is trued up, the inside and outside diameters of the rim scribed, and these dimensions of the rim turned.

From the face of the work, with a marking gage, scribe about the inside circumference the center line of the rim. This center line should pass through the center of the thickness of the tongues *A*.

With the aid of a templet, the turning of one-half of the cross section of the rim is carried to completion as shown.

To rechuck the job, secure to the face plate three blocks, as at *D* (Fig. 371). A 90-degree V-shaped groove turned in the blocks will accurately center the work.

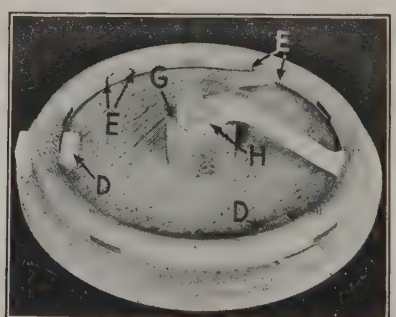


Fig. 371.—Shows how the rim is attached to the face plate for the assembling of the arms.

Screws inserted through the face plate and the blocks are the means of securing the job in place.

At the completion of the turning operation, the points at which the arms are to enter the rim are spaced off upon the center line and the work removed from the face plate.

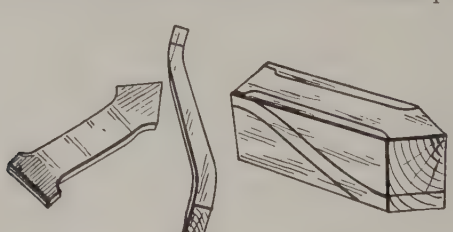


Fig. 372.—Two views of an arm sawed to shape and also the outline of an arm traced upon the stock.

The ends of the openings, as at *E*, which are to receive the arms, are of semicircular form. By giving them this shape, they may be easily and quickly made by using an auger bit of a corresponding diameter.

Since the diameter of the rim will not permit a bit to be used in connection with a brace, a block containing a hole to receive the shank of the bit will do the work.

To assemble the various members, return the rim to its position upon the face plate (Fig. 371).

At the required distance above the center line of the rim, establish, as shown at *G*, a surface upon which to locate and temporarily attach the portion of the hub *H*.

The arms, which should be dressed to their required shape (except as noted below), are next set in place and the remaining portion of the hub attached.

Wheel arms of the shape and proportion dealt with in this case are best shaped by what is termed *countersawing*. Refer to the instructions given with pattern 10 (page 105).

Figure 372 illustrates two arms at the completion of the sawing operation and the outline of an arm laid out upon the material ready to be sawed.

In finishing arms of wheels and spiders to their required shape before assembling, it is usually good practice to allow a little stock for dressing, after they are together, at the points where the arms join the rim and where they meet at the hub.

QUESTIONS

1. What is understood by a three-part lap?
2. How should the hubs of wheel patterns be attached to the spider?
3. Why is the layout of a wheel pattern necessary?
4. Describe the method of letting the spider into the segments.
5. Describe a method of attaching to a face plate small hubs subsequent to the setting of the center dowel.
6. What is a tongue joint?
7. When is a tongue joint used in segmental construction?
8. What was the arrangement employed in rechucking the rim of the brakewheel pattern?

PATTERN 56

SWIVEL

Features presented:
Loose-piece feature
Pattern arrangement
Figure 373 is the drawing of a cast-steel swivel.

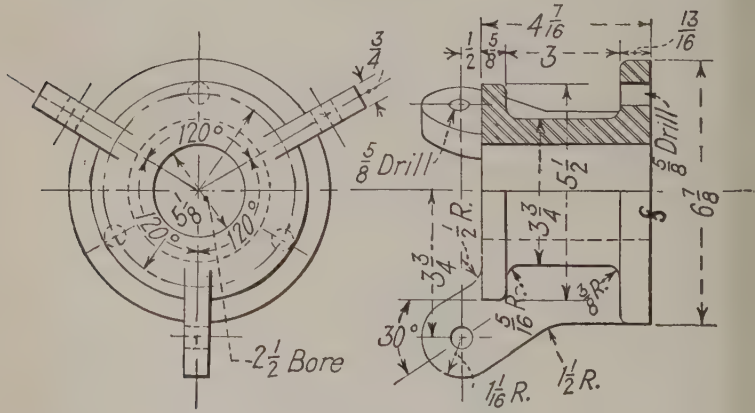


FIG. 373.

The form of the casting is that of a flanged cylinder supporting three ears. This design requires a pattern somewhat difficult to remove from the sand. Although it may be molded horizontally, a vertical position will be found to be more practical. It will also minimize the possibility of ramming the ears out of place.

Figure 374 shows the completed pattern. It illustrates how the protruding loose dowels, as at *A*, are employed to hold the parts intact.

Figure 375 illustrates the pattern with the loose pieces detached. Notice the arrangement of the shoulders B and C upon which the loose pieces rest while the mold is being rammed up. The width of the shoulders is unimportant

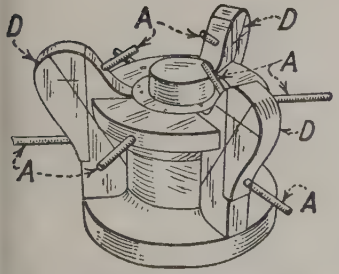


FIG. 374.—Arrangement of the swivel pattern.

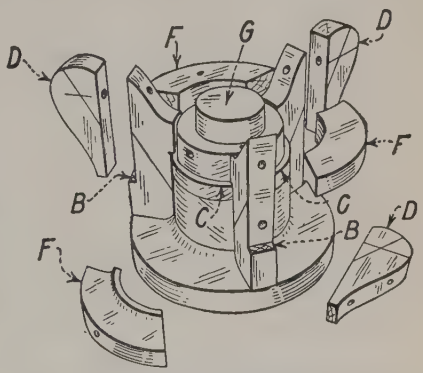


FIG. 375.—The swivel pattern with the loose pieces detached.

and may be readily determined from a radial section layout of the pattern.

Make the body of the pattern by sawing out a cylindrical piece of stock to which attach the flange portion; then turn the work to size. The drag core print G is attached later.

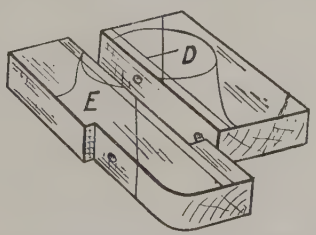


FIG. 376.—The arrangement of the material for the ears.

Figure 376 shows the outline of one of the ears D laid out upon the material. Begin this part of the work by first fitting the material to the body of pattern. Make the joint E between the two parts, and proceed with the laying out. Bore the holes for the loose dowels before sawing the ears to shape.

As the loose part of the ears is drawn back into the depression left vacant by the part attached to the body of the pattern, it should be made slightly less in thickness and drafted accordingly.

When the ears have been attached, the three segments, as at *F*, that comprise the loose flange are fitted into place, and the dowel holes are bored. The loose flange is made by attaching three segments to a face plate and turning up a ring of the required cross section.

The cope core print is of the conventional cone type.

Molding the Pattern.—To mold the pattern, it is placed upon the molding board in the position shown in Fig. 374 and the sand rammed up to the height of the lower dowels of the ears. These dowels are drawn out and the ramming of the sand continued up to and firmly tucked under the loose flange.

In doing this work, care should be taken to hold the flange firmly down upon the shoulder *B*.

The dowels holding these loose pieces are now drawn out and the ramming proceeded with until the upper dowels of the ears are reached and removed. The ramming of the mold is now carried to completion.

Following the removal of the body of the pattern from the sand, a cavity of ample proportion is left into which the loose flange and ear parts are drawn.

Picking Up a Line.—Irregular lines of a layout may be transferred to material by being what is called "picked-up." The procedure is to place at intervals small flat-head brads with the head thickness lying along the line and to press the material upon them. A line drawn through the resulting indentions will be the course of the line.

PATTERN 57

AIR PAN

Features presented:

Tracing interior core outlines

Pattern and core-box arrangement

Figure 377 is the drawing of a cast-iron air pan. The casting is of a shell nature and has a metal thickness of approximately ¼ inch. The interior consists of two distinct chambers.

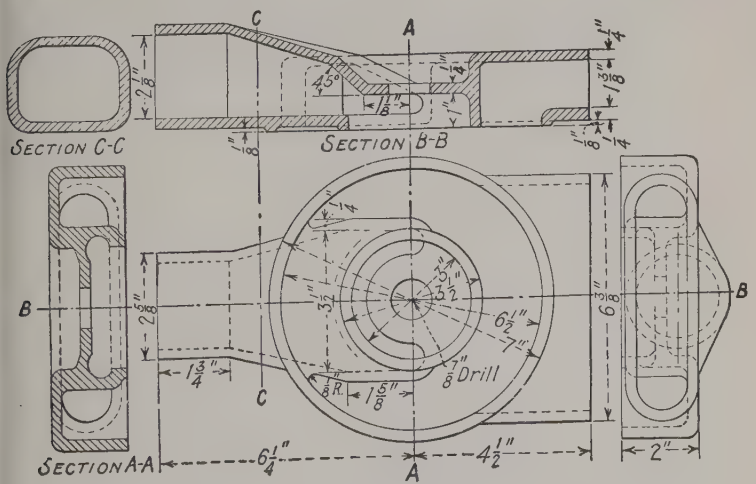
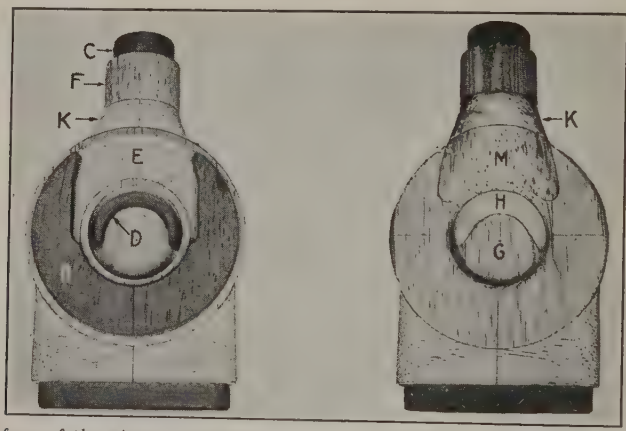


Fig. 377.

Visualizing the shape of a core that is to form the interior of a casting is not always easy, especially for the inexperienced. This feature is frequently clarified by making a carbon tracing from the drawing of the interior outline of the different views of the casting. By the elimination of all exterior lines, the core shapes are more easily discerned.

In a great many cases, the actual construction of a pattern is a matter of opinion. Some workmen may prefer to shape or carve the pattern more or less from one piece of material;



Drag face of the air-pan pattern. Cope face of the air-pan pattern.

FIG. 378.

others may decide upon separate-member construction, as used in the present instance.

An illustration of the drag and the cope face of the pattern is shown in Fig. 378 and a longitudinal section through the center of the pattern in Fig. 379.

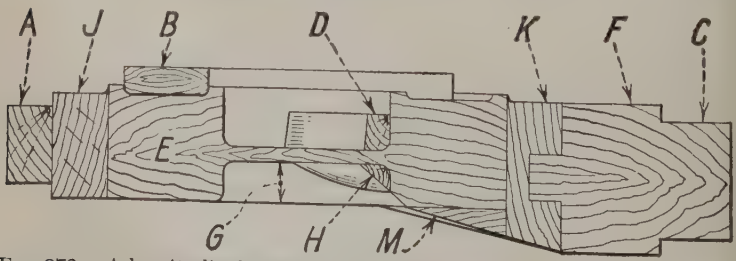


FIG. 379.—A longitudinal section through the center of the air-pan pattern.

The core, which forms the oblong opening and the circular wall of the pan, receives its support through the core prints *A* and *B*. Likewise, the core, which forms the 2⅛-inch diameter pipe-connection opening depends upon the core prints

C and *D*. Core print *D*, as is noted, is of segmental shape. Its height (½ inch) is equal to the thickness of the core forming the opening at this point.

The circular portion *E* of the body of the pattern, which has a depression in each face, is turned, as also is the circular portion of the pipe connection *F* and its attached core print.

Material for member *J* (Fig. 379) is got out to the required thickness and to ample width and length and its shape laid out upon one edge. The circular joint line where it meets the body *E* (Fig. 378) is sawed, and the detached piece of waste

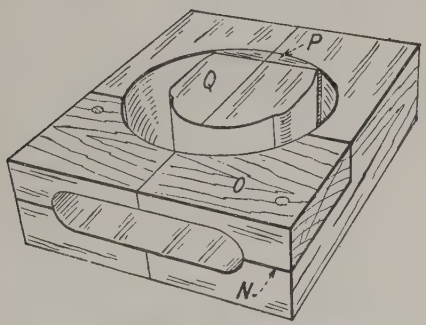


FIG. 380.—One type of core box used in connection with the air-pan pattern.

returned and bradded into place. Sawing and sanding this member to its required cross section follow in order (see Countersawing, page 105).

Core print *A* may be about ¾ inch in thickness. Part *K* is sawed out to its top and side view and attached to part *F* with a dowel joint.

Two ways are afforded in shaping the depression in the body of pattern as at *G* (Fig. 279). One is to carve it from the solid; the other is to turn it to the required depth and to 3 inches in diameter. Then fit and glue in a filling piece of semicircular shape, as at *H*, which is then dressed to the required slope or angle of the wall of the depression at this point. Material *M* (Figs. 378 and 379) is sawed to the shape shown, then glued in place, and dressed to its diminishing thickness.

CORE BOXES FOR AIR PAN

To make the box illustrated in Fig. 380, arrange the joint *N* and dowel piece *O* in place, and turn out the circular depression. Dress to shape the oblong opening next; then shape parts *P* and *Q*, and attach them in place. Part *Q* should be attached with dowels.

Figure 381 illustrates the other core box required. The parting of this box requires that an oblique shoulder be made

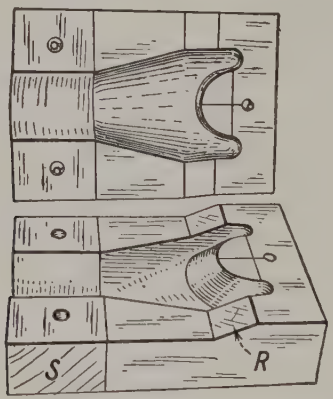


FIG. 381.—The core box that forms the pipe connection of the casting.

as at *R*. Shape the cavity in part *S* of box; then attach it to the adjoining material, and proceed to carve out the remainder of the cavity.

A Working Model.—Making a rough model of a casting is often well rewarded by one being better able to determine the most economical procedure for the molding of the pattern, as well as that of its construction.

PATTERN 58

BEVEL GEAR

Features presented:

Shaping the teeth of solid gear patterns
Band-saw practice
Sanding-roll practice
Application of jig

Figure 382 is the drawing of a cast bevel gear with a pitch diameter of 6.565 inches, a circular pitch of 1.375 inches, and 15 teeth.

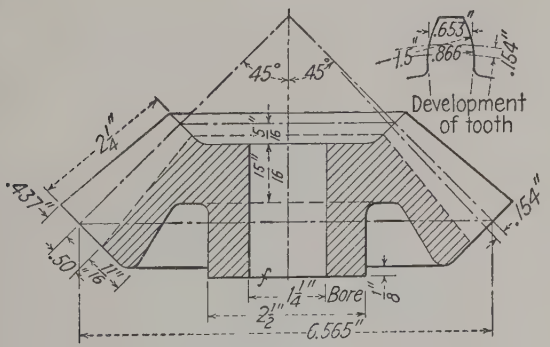


FIG. 382.—Cast bevel gear.

While gears with cast teeth have been practically replaced by the more efficient machine-cut teeth, the former continue to be used to some extent. For this reason and because the shaping of cast-teeth patterns involves operations applicable to many other forms, an outline of this work is given.

For small solid spur- and bevel-gear patterns there is no better manual method of shaping the teeth than that afforded by the band saw. To do this work and keep within a toler-

ative degree of error demands a true running, evenly set, and narrow saw blade, plus a steady hand. The root fillets of the teeth may be struck, but planted leather fillets will expedite the work.

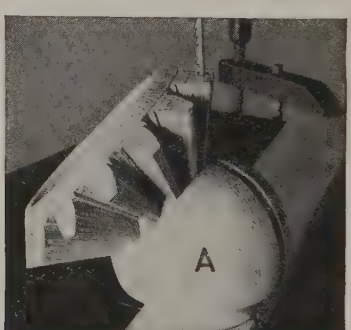


FIG. 383.—Setup for shaping the teeth of a 90-degree solid pattern for bevel gear.

Shown in Fig. 383 is the setup employed in sawing the teeth of a 90-degree bevel gear. By maintaining the gear blank upon a spherical support, as shown at *A*, the conditions for

FIG. 384.—Setup for shaping the teeth of a 120-degree solid pattern for bevel gear.

correctly forming the teeth are produced. This is due to the fact that all the elements of the teeth are made to converge at the apex of their cone, which is the center of the spherical

surface of the ball support. In cases where interference occurs between the ball and the blank, as will occur in the present case, the surface of the blank surrounding its axis is to be further depressed. Following the sawing of the teeth, the depression is to be filled in.

A bevel gear of an obtuse angle as that shown in sawing

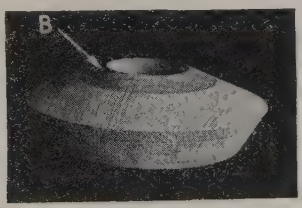


FIG. 385.—Bevel-gear blank with temporary socket in place.

position in Fig. 384 will likely require the filling in of material about its axis and a spherical socket turned as shown by the shaded portion *B* (Fig. 385).

Individual layouts may be made of each tooth, but a more accurate and practical method is to trace their outlines, from a zinc templet, which is swung from the axis of the work.

To set up a gear blank correctly in sawing position, the width

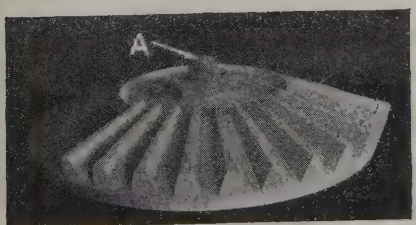


FIG. 386.—Built-up body of bevel-gear pattern with teeth attached.

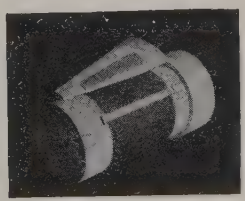


FIG. 387.—Jig and sanding roll.

of the points of the teeth must be outlined upon its conical surface. This can be accurately accomplished only by either turning a complete conical surface or establishing its apex as shown at *A* (Fig. 386). It is at this exact point that all elements of the teeth must converge.

No better way has been devised for shaping the teeth for a

built-up pattern body as shown in Fig. 386 than that of sanding. By shaping a jig and arranging a roll as shown in Fig. 387, the duplication of the teeth for spur- or bevel-gear patterns is assured. Two screws hold the blocks within jig.

The method of developing the tooth outline upon the oppo-

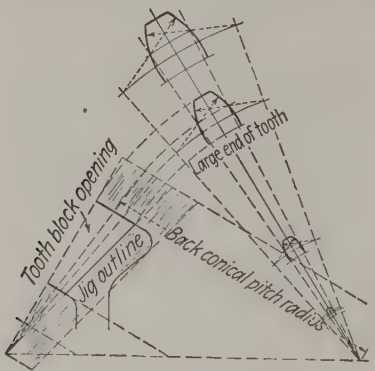


FIG. 388.—Tooth-jig development.

site ends of the jig material is shown in Fig. 388 and should need no explanation.

In making the roll the sandpaper is to be attached first; then the diameter of the guiding surfaces of the roll turned to conform to the sanding surface. If the paper is slightly

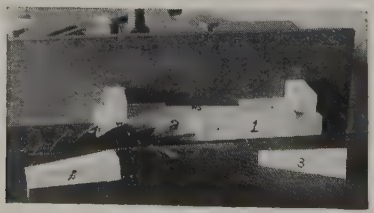


FIG. 389.—Shaping the tooth blocks.

moistened, it will more readily adapt itself to mounting and will also hug the roll more closely.

Aided by a three-place wedge jig as shown in Fig. 389, the tooth blocks may be easily sawed to their diminishing cross section.

PATTERN 59

WORM

Features presented:

Shaping the thread of worm patterns
Band-saw practice
Application of jig templet
Attaching loose core prints

Figure 390 is the drawing of a right-hand, single-thread cast worm with a pitch diameter of $4\frac{1}{2}$ inches and an axial pitch of $1\frac{1}{2}$ inches. The thread has straight sides, which incline at an angle of 15 degrees.

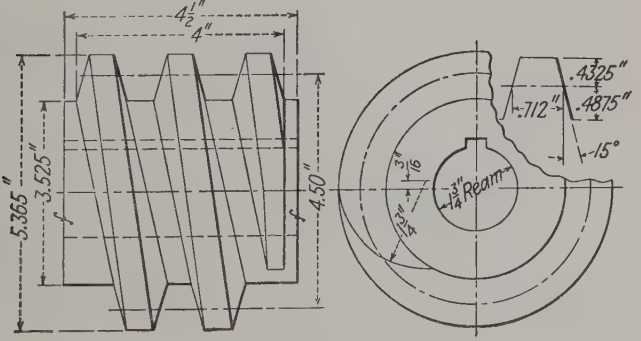


Fig. 390.

Shown in Fig. 391 is the setup of the table for sawing the semicircular thread segments to their exact cross sections. To perform this operation, the saw table is tilted to an angle of 15 degrees and the angle of the cylindrical support *A* determined through trial and careful adjustment. If the angle of the cylindrical support has been correctly made and a true running and narrow saw blade used, very little pressure will

cause the saw to follow the course of the helical lines of the thread, as traced upon the material.

One-half of the incompleted drag section of the pattern with its portion of the thread attached is shown in Fig. 392. The cope portion of the thread is shown to the left. In attaching the thread segments to the drag body of the pat-

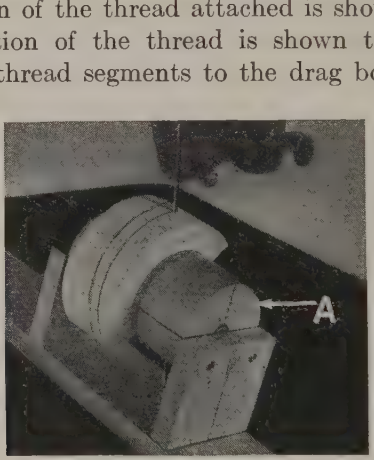


FIG. 391.—Setup for shaping the thread of the worm pattern.

tern, secure this member over the layout of the worm, then locate the segments accordingly. The cope half of the thread is to be assembled upon the drag half of the pattern.

Removing the saw marks from the thread is done with the aid of a sanding strip, whose cross section is made to corre-

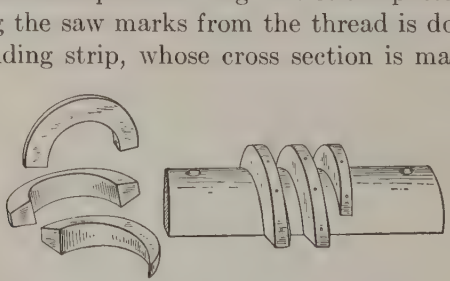


FIG. 392.—Worm pattern in process of completion.

spond to that of the space between the thread. By gluing a medium grade of garnet paper to one of the side surfaces and holding the strip in place while revolving the lathe by hand, the sides of the thread can be accurately finished.

The segment from which a section of the thread is sawed is

shown at *A* (Fig. 393). To trace the width of the thread as represented by the parallel lines, the jig templet, as at *B*, is used. This device consists of a semidisk base about which cardboard is attached, the top edge of the cardboard representing the angle of the thread at its point. To trace the two lines as shown, the jig is used with and then without the insert, as at *C*. The angle for the edge of the templet is

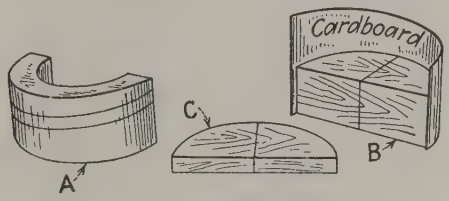


FIG. 393.—Jig-templet used in tracing the outline of the thread upon the material.

obtained from a layout of a right-angle triangle whose base is equal to the circumference of the thread and the perpendicular equal to the pitch of the thread.

If one-half of the pattern is placed upon a surface plate and the sides of the thread tested, it will show that back draft occurs at a point near the parting of the pattern. To over-

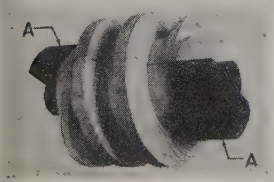


FIG. 394.—Completed worm pattern.

FIG. 395.—Shows the separated parts of the pattern.

come this condition, it will require that the pattern be revolved about 18 degrees before being drawn. This action will cause the pattern to move forward about $\frac{3}{16}$ inch. To provide space into which the pattern may enter, the core prints *A* (Fig. 394) are drawn first and are attached with dovetail keys as shown at *B* (Fig. 395).

PATTERN 60

WORM GEAR

Features presented:

✓Pattern provision

Molding practice

Core-box arrangement

Figure 396 is the drawing of a right-hand, cast-tooth worm gear with a pitch diameter of 19.098 inches, a circular pitch of 1.50 inches, and 40 teeth.

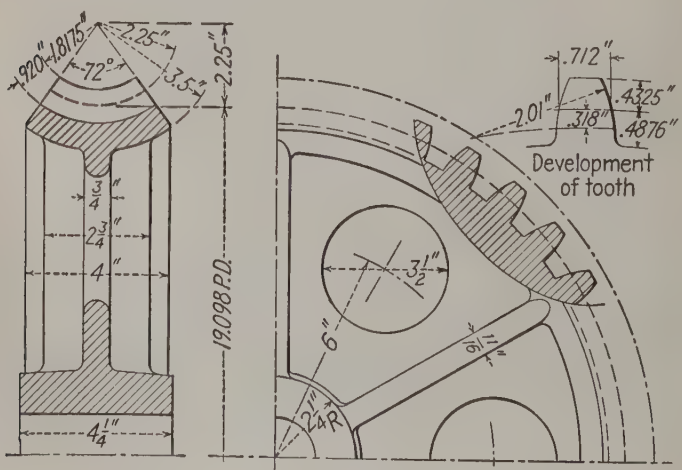


Fig. 396.

Accuracy is the goal sought in the casting of gear teeth, and therefore every operation must proceed in a way that will promote this feature. The teeth of these gears are usually given shape through the use of segmental dry-sand cores. These cores are set into a circular seat which is formed by the

core print *A*, as shown by the pattern Fig. 397. It is important that a liberal amount of taper be given the core print and the diameter of the print be so proportioned as to provide ample bearing surface for the correct registering of the core segments. Making the cores extend above the surface of the

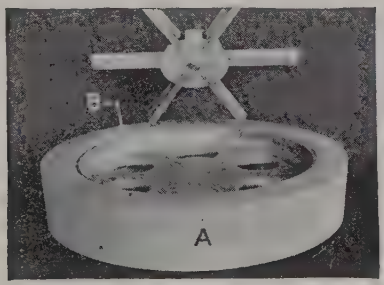


FIG. 397.—The worm-gear pattern.

rim, as indicated by the print at *B*, avoids a thin edge of sand that would otherwise occur at this point.

It must be borne in mind that in making boxes for segmental cores of this nature, the shorter the cores, the less likely they are to become distorted. For gears of an even

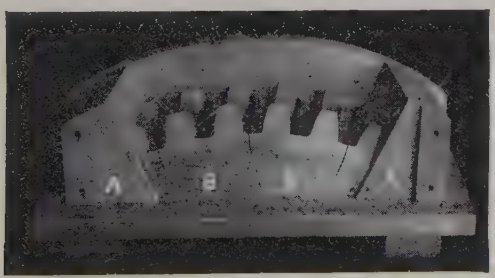


FIG. 398.—The structural features of the core box.

number of teeth, the length of the box should be such as to contain its proportional number of teeth. In the event of an uneven number of teeth, the number is to be divided so as to permit one of the cores to be stopped off.

By dividing the 40 teeth of the gear discussed among 8 cores, each core will contain the impression of 5 teeth and will

therefore give the core segments a length of $7\frac{1}{2}$ inches along the pitch circle.

An open view of the box, as shown in Fig. 398, clearly gives its structural features. To facilitate the removal of the tooth patterns with the least disturbance to the sand, the root or foundation block is separated into four parts as designated by *A* and *B*. Close attention is to be given to the shaping of the end sections *A*, to which a one-half tooth is attached, for it is upon their radial surfaces that the correct spacing of the cores will depend. Compensation is made for the saw kerf separation of the foundation block by affixing cardboard to the sawed surfaces.

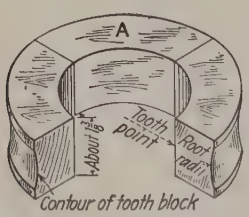


FIG. 399.—The ring from which the tooth segments are sawn.

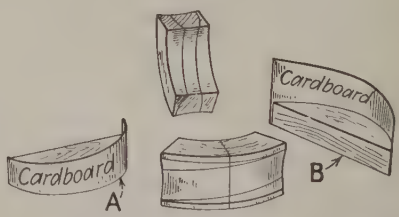


FIG. 400.—Jig-templets used in tracing the outlines of the teeth upon the material.

To allow for the swelling of the cores, a clearance of $\frac{1}{64}$ inch at each end should be sufficient. However, it is a good practice to make a number cores and check this feature.

Rings from which tooth segments are sawed from the opposite sides, as at *A*, are turned to the shape shown in Fig. 399.

Jig templets, similar to the one used for outlining the thread of a worm pattern, are also used for the teeth of worm gears and are shown in Fig. 400. Jig *A* is employed in the outlining of the point thickness of the teeth and jig *B*, for the root thickness. To draw a pair of lines, the position of the material is reversed within the jig.

Sawing the teeth to their root thickness is accomplished with the aid of a cylindrical support setup as shown in Fig. 391 (page 324). The face surfaces of the teeth are to be dressed to shape with the aid of a thin-edge, negative-shaped templet.

PATTERN 61

MANIFOLD

Features presented:

Maximum use of the machine tools

Combination core-box arrangement

Figure 401 is the drawing of a cast-iron manifold used in connection with a marine motor. In general, the casting consists of two cylindrical shells, one within the other, as shown by the cross section of the casting at *A-A*. A casting of this type is usually referred to as having a water-jacket.

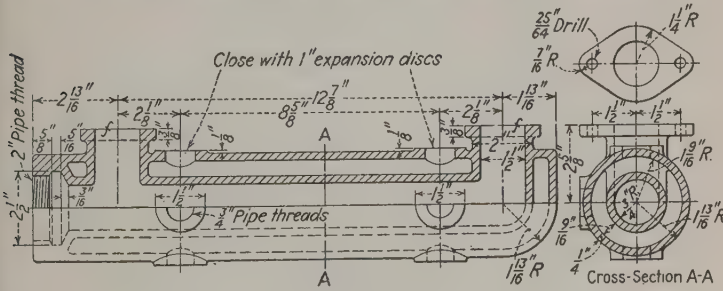


Fig. 401.

Since a manifold receives the hot gases directly from the cylinders, some system of keeping the manifold cool is necessary and is accomplished in this case by causing a circulation of water to pass through the chamber separating the two shells. The holes that admit and discharge the water from the chamber are the only two holes required in the finished casting that pass through its outer shell. The cores that form these openings are not only inadequate to support the chamber core within the mold, but the openings produced by them are insufficient for the removal of the core from the casting. To provide such provisions, four openings, not required in the

finished casting, are made through the outer shell. The locations of these openings are shown on the drawing and their core prints indicated by the letters *A* in the illustrations of the pattern shown in Figs. 402 and 403. During the finishing of the casting, these holes may be threaded and pipe plugs

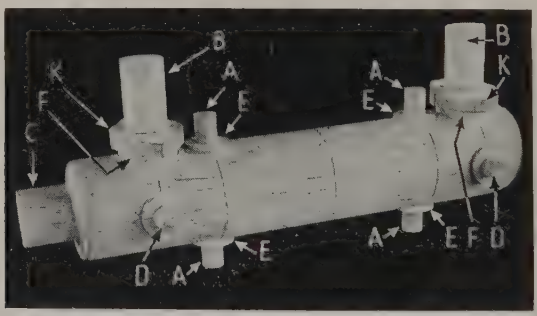


FIG. 402.—The pattern for the manifold casting.

inserted and the heads of the plugs cut off flush with the face of the bosses, or they may be closed with expansion disks. Holes that are to be threaded to receive pipes are usually cored out to a diameter equal to that of the pipe specified. The core prints *B* and *C* are the means of registering in the

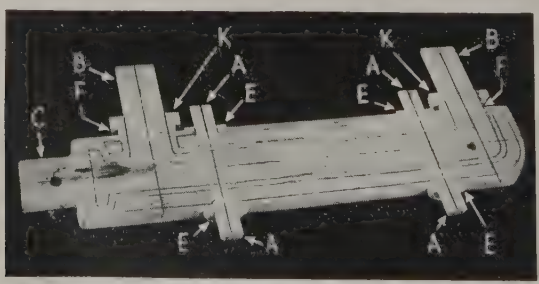


FIG. 403.—The drag half of the manifold pattern showing the layout made upon the parting surface.

mold the core forming the exhaust chamber. Observe the unusual length of the core prints *B*. These prints are made about 2½ inches long. They are made this length for the purpose of balancing the core in the mold and to help resist the upward pressure exerted by the molten metal.

The core-seat depressions left in the sand by the prints *D* (Fig. 402) locate the cores forming the water intake and discharge openings of the water chamber. A layout of a job of this nature is chiefly required for the proportioning and making of the core boxes and may be directly made upon the parting surface of the drag half of the pattern (connections excepted) as shown in Fig. 403.

A manifold pattern of this design affords an excellent example to show what may be accomplished through the maximum use of the machine tools. All joint surfaces of the pattern are completed upon the jointer, circular saw, and band saw. The bench tools will include turning tools, plane, auger bit, and a firmer gouge.

Attention is called to the circular bosses indicated by the letters *E* and *F* (Figs. 402 and 403). These bosses are located upon the parting line of the pattern and therefore must be parted. They are shaped as one piece by attaching with glue along one edge, as at *G* (Fig. 404) two pieces of material. Following the outlining of the circular joint surface *H* and the circumference *J*, the work is shaped by countersawing and disk sanding. A saw cut made along the glue joint *G* will separate the two parts.

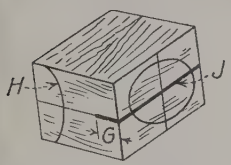


FIG. 404.—Arrangement of the material for shaping the bosses *E* and parts *F*.

Locate the position of the bosses *E* upon the parting line of the body, and glue in place (do not nail). This work should be performed upon a flat surface without the aid of any clamping device. Allow the glue to set for a few moments; then saw the bosses to the required length upon the circular saw. Now repeat the operation for the parts *F*, but in sawing these parts to length, the saw table is to be tilted so as to conform to the angle of draft allowance upon the back of the flanges *K*. Shaping and attaching the flanges *K* require no explanation.

The bosses upon which the core prints *D* are located are shaped in practically the same manner as the bosses *E*. They are glued in place and also sawed to length, as explained.

Dowels turned upon the core prints *A* and *B* are the means of fastening these members in place. The holes for the dowels are bored in the parting joint with an auger bit. All joints are to be reinforced with nails.

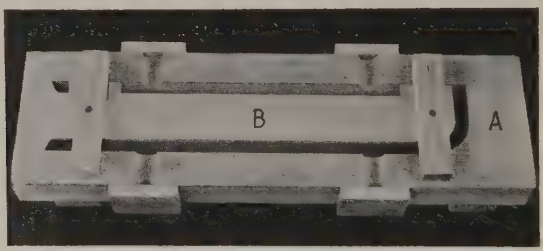


FIG. 405.—The combination core box used in forming one-half of the water-chamber core.

CORE BOXES REQUIRED

In the arrangement of cores for castings of this nature, it is essential that the core boxes be accurately made, for a slight degree of error will probably prevent the cores from registering correctly in the print depressions in the mold, thereby causing an uneven distribution of the metal.

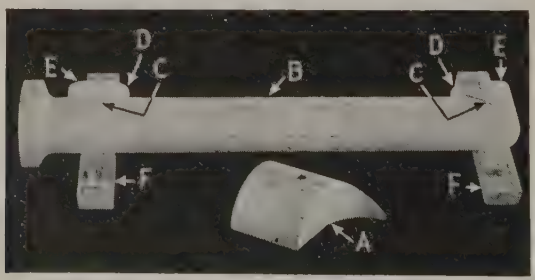


FIG. 406.—Change pieces used in connection with the combination core box for water-chamber core.

Figure 405 illustrates the core box employed in forming one-half of the water-chamber core. The change piece *A* and *B* used in forming the opposite half of this core are shown in Fig. 406.

All semicircular cavities are shaped upon the circular saw and the saw marks removed with a sandpaper roll. The change blocks *A* are sawed and disk-sanded to their semicircular form. They are then attached in place with a dowel

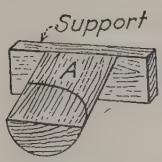


FIG. 407.—Manner of supporting the work for sawing of the change pieces *A*.

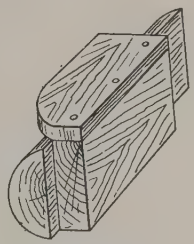


FIG. 408.—The arrangement of the jig for sawing the arc of the ends of part *D*.

and the shape of the end of the cavity outlined upon it. For the sawing and spindle-sanding operations, the face surfaces of the work are maintained parallel to the table by attaching

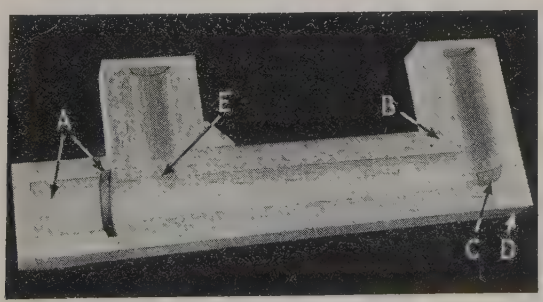


FIG. 409.—One of a pair of core boxes required to form the exhaust outlet core.

a support across the end, as shown in Fig. 407. This method is also used for the sawing of the V-shaped joints *C* used in attaching the parts *D* (Fig. 406). The arc of the ends of the parts *D*, as indicated by *E*, are sawed to shape with the aid of

a jig, as shown in Fig. 408 and should follow the operation of sawing the V-shaped joint surfaces *C*.

Dowel pins in the cleats *F* (Fig. 406) locate and hold part *B* in its proper relation to the body of the box, as shown.

Figure 409 illustrates the type of core box used in forming the exhaust outlet core. A pair of these boxes are required. With the exception of the cavities indicated by *A*, which are sawed and spindle-sanded to shape, the main cavity and its branches were shaped upon the circular saw, as previously explained. The use of a miter joint, as at *B*, produced a right-angle turn but did not form the curve of the turn indicated by *C*. The material *D*, out of which the curved surface is carved, is set into the corner as shown. The surface *C* and the part of the cavity that is cut out at *E* required the use of a firmer gouge.

QUESTIONS

1. Name two methods of shaping gear-teeth patterns.
2. Give the requirements demanded for sawing tooth patterns.
3. How are the teeth of bevel-gear patterns sawed to shape?
4. State the principle involved in sawing these members.
5. How should a templet be used in outlining the teeth?
6. How may a number of tooth patterns be accurately duplicated?
7. How is sandpaper to be treated before mounting it on roll?
8. Describe the saw setup for shaping worm-pattern threads.
9. How are worm-pattern threads to be finished in a lathe?
10. Give reason for semidisk core print on the worm pattern.
11. What is a dovetail key and when is it used?
12. What was learned from the worm-gear pattern?
13. Why were short-tooth segment cores used?
14. What is a jig templet?
15. What may be done to clarify the interior outline of a casting as represented by the drawing?
16. What may be done when cored openings in some castings are inadequate for the removal of the core?
17. How did making the layout of the manifold pattern upon the parting surface of the material expedite the work?
18. What were the distinct features presented by the manifold pattern?
19. How was a combination core box used in forming the core for the water chamber of the manifold casting?

THE CHECKING AND THE INSPECTION OF PATTERNS

The checking and the inspection of patterns demand a reasonable degree of judgment, a *thorough understanding* of mechanical drawing, pattern practice, and foundry ways and means.

The degree of accuracy to which a pattern is built should correspond to the purpose for which the casting is intended. That is, a difference of $\frac{1}{16}$ inch or even more may be of no consequence in the dimensions of some castings, whereas in others the given dimension demands the quantity stated. Hence, whenever in doubt *adhere* to the dimension on the drawing.

The first step in checking a pattern is to obtain from the drawing a clear understanding as to the nature of the casting and to avoid any influence that the pattern might have upon this interpretation.

The second step is to consider the pattern for its economical molding qualities. Next, observe its exterior details to see that all members shown on the drawing are represented; then take notice that the core prints, if any, will afford ample support for the cores, and so on. Lastly, see that facilities have been provided for the rapping and the drawing of the pattern.

To be effective, checking must be done in an absolutely systematic manner and with *thorough concentration.* Taking the measurements will depend somewhat upon the nature of the pattern, but it is obvious that doing this work upon a surface plate will give the most accurate result. If a slight check mark is not objectionable, it is a good practice to place a small check above all verified dimensions with a contrasting crayon color. This will indicate at a glance how far the work has progressed and is especially helpful if interruptions are likely to occur.

Start with the plan view and check first the location of the base center line. From this line check the location dimensions; then verify the over-all dimensions. Beyond that of comparison, do not bother about the other views but complete one view at a time. If corrections are to be made upon the pattern, they should be so indicated upon the drawing.

Where core boxes are involved the same checking practice is to apply. Particular attention is to be given the print registering surfaces of the cores so that these sand bodies may be accurately set in place. No matter *how simple it may appear*, if a core can be set into a mold in any other position than that intended it should be registered.

If holes are required in a core box for the insertion or for the withdrawal of venting rods, such holes should be bored.

To facilitate the setting, the shape or weight of a core may often require that lifting staples be embedded in the top surface. The position of such staples should be indicated upon the side of the box.

Classification of Patterns.—Patterns are classified as standard, medium, and temporary. **Standard** patterns are those used constantly or at frequent intervals. They are to be so constructed as to withstand a long period of use. Every feature that might expedite the making of the mold should be embodied in their arrangement. Patterns of this type should be returned at intervals to the shop for revarnishing and for minor repairs. **Medium** patterns are those used occasionally and may therefore be of a cheaper nature. However, the quality of the material used and the features of construction should be such that the pattern will retain its accuracy of form and dimensions. **Temporary** patterns are used when only one or two castings are required. They are made as cheaply as the case will permit. Patterns of this type, although saving in pattern cost, often require extra work on the part of the molder in the finishing of the mold.

Skeletonized patterns are generally used in the molding of large hollow castings. They consist of a skeleton or frame that represents the interior and exterior form and the metal

thickness of the required castings. The members of the structure form narrow surfaces to guide the strickles used to complete the surface of the mold.

Recording of Patterns.—All firms requiring objects cast in metal have a system of recording their patterns. It is a common practice to affix a raised number on the pattern so that it will appear in the casting. The number is the means of keeping a record of the pattern, of identifying the casting, and of checking the order list. To keep a record of the location and movements of a pattern, a card index is used. The card gives a full description of the pattern, its location in storage, and the dates of its delivery to and return from the foundry. A record card similar to the form shown is made out in duplicate, one copy to be retained by the drafting division and the other by the pattern department.

PATTERN RECORD CARD

NILSAC ENGINEERING COMPANY Date

Pattern No.	Contract No.	Drawing No.	Metal
Grade of pattern	Man-hours	Lumber required	Pattern cost

Name and the description of pattern

Number of pieces | of core boxes | of standard cores

Altered	Drawing No.	Contract No.	Date	Alt. Symbol

Further alterations

Storage location	Section	Floor space	Shelf

Further information

Over

Areas

Rectangle or parallelogram = base × perpendicular height
Square or rhombus = ½ the product of its diagonals
Polygon (reg.) = sum of sides × half perpendicular distance from center to sides
Triangle = base × half perpendicular height
Circle = diameter squared × 0.7854
Sector of circle = length of arc × half radius
Ellipse = long diameter × short diameter × 0.7854.

Lengths

Circumference of circle = diameter × 3.1416
Diameter of circle = circumference × 0.3183
Diagonal of square = distance across flats × 1.414
Length of arc = number of degrees × diameter × 0.0087
Sides of an inscribed square = diameter of circle × 0.7071

Volume of Solids

Prism or cylinder (right) = area of end × length
Pyramid or cone (right) = area of base × ⅓ the altitude
Sphere = cube of diameter × 0.5236

Decimal Equivalents of Fractions of an Inch

1/64	.0156	17/64	.2656	33/64	.5156	49/64	.7656
1/32	.0313	9/32	.2813	17/32	.5313	25/32	.7813
3/64	.0469	19/64	.2969	35/64	.5469	51/64	.7969
1/16	.0625	5/16	.3125	9/16	.5625	13/16	.8125
5/64	.0781	21/64	.3281	37/64	.5781	53/64	.8281
3/32	.0938	11/32	.3438	19/32	.5938	27/32	.8438
7/64	.1094	23/64	.3594	39/64	.6094	55/64	.8594
1/8	.125	3/8	.375	5/8	.625	7/8	.875
9/64	.1406	25/64	.3906	41/64	.6406	57/64	.8906
5/32	.1563	13/32	.4063	21/32	.6563	29/32	.9063
11/64	.1719	27/64	.4219	43/64	.6719	59/64	.9219
3/16	.1875	7/16	.4375	11/16	.6875	15/16	.9375
13/64	.2031	29/64	.4531	45/64	.7031	61/64	.9531
7/32	.2188	15/32	.4688	23/32	.7188	31/32	.9688
15/64	.2344	31/64	.4844	47/64	.7344	63/64	.9844
1/4	.25	1/2	.5	3/4	.75	1	1.0

GLOSSARY OF PATTERNMAKING AND MOLDING TERMS

air-dried lumber.—Lumber seasoned by being permitted to dry out naturally.

alloy.—Any composite metal produced by the mixing of two or more metals.

aluminum.—A light, white metal obtained from clays.

back draft.—Is applied to a surface of a pattern requiring draft but the draft is trending in the wrong direction.

baked core.—Formed body of core sand that has been subjected to heat.

balanced core.—One with the core seat so proportioned that it will overbalance that part of the core extending into the mold cavity.

barrel.—A cylindrical body long in relation to its diameter and either hollow or solid.

batten.—Wooden bar or strip fastened to patterns to hold them straight or to prevent distortion through the ramming of the mold.

bedding a core.—Resting an irregular-shaped core upon a bed of sand for drying.

bedding in.—Sinking a pattern down into the sand to the desired position and ramming the sand about it.

blacking.—A thin facing of graphite or powdered charcoal brushed or dusted over the surface of a mold to protect the sand from the hot metal.

boss.—A projection on a casting of circular cross section.

bottom board.—A rough board similar to a molding board upon which the finished mold rests.

brass.—An alloy composed chiefly of copper and zinc.

bronze.—An alloy composed chiefly of copper and tin.

bulb sponge.—Combined rubber bulb and sponge. See Swab.

cant.—Shaped material used in building a laminated structure.

cap core.—A core superimposed upon a pattern to complete a portion of the mold cavity not given shape by the pattern.

cast iron.—The most common of metals, mined as iron ore.

cast steel.—Cast iron hardened and toughened by one of various steel-making processes.

casting.—Metal object cast to the required shape as distinct from one shaped by a mechanical process.

center line.—Well-defined knife or gage line placed upon the work to serve as a basis from which dimensions are to be measured.

chamfer.—To bevel a sharp edge.

chaplet.—Metal supports used to hold a core in place when the size of the core seat is inadequate.

cheek.—The section or sections of a flask lying between the drag and the cope.

chuck.—Any of the various devices for holding work in a lathe.

cleat.—Wooden bar or strip as fastened to molding boards to support and prevent distortion.

collapsible pattern.—A pattern so constructed as to permit its removal from the mold in sections.

combination core box.—A core box that may be altered to form a core of another shape.

contraction.—The amount that the metal will have decreased in size from the time it is poured to the time the temperature has fallen to that of normalcy.

contraction rule (also termed shrinkage rule).—A rule having the graduations so enlarged as to compensate for the lessening in the size of a casting caused by the decreasing action of the cooling metal.

cope.—The top section of a flask.

coping out.—The extension of the sand of the cope downward into the drag where it takes an impression of a pattern.

copper.—A metal of reddish color, mined as copper ore.

core.—That part of a mold or body of sand which forms a hole, a recess, or the interior of a casting. Particularly applied to those bodies of sand formed within a core box and subsequently baked.

core arbor.—Cast-iron grid or bar embedded in large cores for means of support and handling.

core binder.—Material mixed with core sand to hold the grains together.

core box.—Specially constructed form into which sand is rammed to give the required shape to a core.

core cavity.—The interior form of a core box that gives shape to the core.

core compound.—Commercial mixture used in core sand to hold the grains together. See Core binder.

cored construction.—Refers to a casting whose interior is formed by a dry-sand core or cores.

core dryer.—A metal shell that conforms to the shape of the area of a core upon which it rests while drying.

core frame.—Frame of skeleton construction used in forming intermediate- and large-sized cores.

core lock.—Matched surfaces so formed upon contacting core bodies as to assure their correct registering.

core-made mold.—A mold assembled from dry-sand core bodies.

core marker.—A core seat so shaped that the core will register correctly when placed in the mold. See Marking a core.

core oven.—Specially designed oven in which cores are baked.

core plate.—Metal plate used to support cores while they are being baked.

core print.—That part of a pattern which has been so designed as to form a seat to locate and support a core within a mold.

core sand.—Sand free from clay, nearly pure silica, or any sharp sea sand.

counterbore.—The cylindrical enlargement of the end of a hole for receiving and setting below the surface the head of a screw.

cover core.—A core set in place during the ramming of a mold to cover and complete a mold cavity partly formed by the withdrawal of a loose part of the pattern.

crossbar.—Wood or metal bar placed in a flask to give greater anchorage to the sand than is afforded by its four walls.

cross section.—A view of the interior of an object that is represented as being cut in two, the cut surface presenting the cross section of the object.

cupping.—The tendency of tangential sawed boards to curl away from the heart of the tree.

cutting over.—Turning over sand by shovel or otherwise to obtain a uniform mixture.

cutting shellac.—Dissolving shellac in alcohol.

dovetail key.—Wedge-shaped tongue with beveled edges used to attach loose pieces to the body of a pattern.

dowel.—A pin of various types used on the joint between the sections of parted patterns or core boxes to assure their correct registering.

draft.—The angle of slant tending away from the line of parting given to those surfaces of a pattern which would lie in the direction in which the pattern or its component parts are drawn from the sand.

drag.—the bottom section of a flask.

draw plate.—Metal plate set into a pattern to facilitate its drawing.

drawback.—Portion of a mold supported upon an iron plate which is so arranged that it may be drawn back for the removal of the pattern.

drawing.—Removing a pattern from the sand.

drop.—The falling of an overhanging body of sand into the mold.

drop core.—Applies to a type of core used in forming comparatively small openings occurring above or below the parting. The seat portion is so shaped that the core is easily dropped into place.

ear.—Usually refers to a comparatively thin, rounded, end projection of a rectangular cross section.

false chuck.—Sometimes applied to the facing material used in rechucking a piece of work in the lathe. See Chuck.

false cope.—Temporary cope used only in the forming of the parting surface and therefore not a part of the finished mold.

false side.—An intermediate loose panel supporting projections or depressions set against the inside of a core box or frame.

fan construction.—Form of stepped-up work with the grain of the wood radiating from a common center.

feather edge.—Edge of zero thickness.

ferrous.—Relating to or containing iron.

file finish.—Finishing a metal surface with a file.

fillet.—Concave corner piece used at the intersection of surfaces. A struck fillet is one that is dressed to shape in place. A planted fillet is one that is made separately and affixed in place.

fin.—A thin projection or ridge occurring on a casting at the point where two sections of the mold come together.

finish allowance.—An amount of stock left upon the surface of a casting for the operation of machine finish.

finish mark.—A V or ƒ-form symbol appearing on the line of a drawing that represents the edge of the surface of the casting to be machine-finished.

flange.—A stiffening member or the means of attachment to another object.

flask.—Frame consisting of two or more sections made of wood or metal and used to enclose the sand in which a mold is formed.

flask pins.—Pins and corresponding sockets on the joint of the sections of a flask to permit their separation and registering.

follow board.—Board having its surface formed so as to support a pattern and to coincide with its parting line.

foundation members.—Permanent or temporary members over which a pattern is built.

founding or foundry practice.—An enterprise or a department of such where molten metal is given shape by being poured into molds made of sand.

gagger.—An L-shaped rod used to reinforce and help to support the sand of the cope.

gate.—Channel that conducts the metal from the sprue to the mold cavity.

gate cutter.—U-shaped piece of sheet brass used in forming a gate.

green sand.—Sand containing sufficient refractory clay substance to bond strongly without destroying the venting quality when rammed to the required degree of hardness.

green-sand core.—Body of sand usually formed directly from a pattern in making the mold.

grind.—Truing up the surface of a casting with an abrasive wheel or belt.

gypsum.—Mineral from which plaster of Paris is produced.

head.—See Riser.

heading.—Permanent or temporary heads over which lags or staves are laid.

horn gate.—A circular-shaped gate or sprue form having a rectangular or round cross section, used when the molten metal is to enter the mold cavity well below the parting line.

hub.—A projection which is round or otherwise and is usually the center of some rotary movement.

intercasting.—The casting of interlinking members.

jig.—Any device so arranged that it will expedite a hand or machine operation.

jig templet.—Any device made to receive and hold a piece of material for checking or outlining.

kiln dried.—Lumber artificially dried by being placed in a specially designed enclosure called a *kiln.*

kiss core.—A core that contacts another core or is set against the side of a pattern to supply a portion of the mold cavity not furnished by the pattern.

lagging.—The fastening of narrow lags or strips about batten foundations so shaped as to follow a line parallel to the contour of the pattern.

laminated construction.—Building up in a series of courses a pattern structure of strips or segments with the alternating end joints occurring midway between those of the preceding course.

layout board.—A board upon which a layout of a pattern is made.

lifting hooks.—Form of staples embedded in cores to facilitate handling and setting.

locking surfaces.—See Core lock.

loose flange.—Flange member that may be drawn independently of the body of a pattern and is often used in combination with a covering or slab core.

loose piece.—Part of a pattern so attached that it remains in the mold and is taken out after the body of the pattern is drawn.

lug.—An earlike projection that is frequently split as the clamping lug on the tail stock of a lathe.

machine finish.—Operation of turning or cutting from the surface of metal an amount of stock in order to produce a finished surface.

magnesium.—Silvery white metal, one-third lighter than aluminum, obtained from ocean water or from subterranean brine.

malleable cast iron.—Cast iron made ductile through an annealing process.

marking a core.—Shaping the core print portion of a core and its seat so that the core cannot be misplaced within the mold.

master pattern.—A pattern embodying a special contraction allowance and used for making castings that are to be employed as patterns in production work.

match plate.—Wood or metal plate to which a pattern is attached at its parting line.

matched parting.—Forming of a projection upon the parting surface of the cope half of a pattern and a corresponding depression in the surface of the drag.

medium-grade pattern.—A pattern used occasionally which may therefore be of a cheaper nature than a standard pattern.

metal cavity.—See Mold cavity.

mill thickness.—The thickness of lumber as it is sawed from the log.

mold.—As applied to founding is a body of sand containing the impression of a pattern.

mold cavity.—Impression left in the sand by a pattern.

molding board.—Board reinforced with cleats having a true surface upon which a pattern is laid for the ramming of the drag.

multiple molds.—Series of molds stacked one upon another and poured from a common runner.

multiple sawing.—Duplicating in one sawing operation a number of forms by stacking the material.

one-piece pattern.—Solid pattern but not necessarily made from one piece of wood.

open construction.—Refers to castings of a frame or open nature.

open mold.—Copeless mold used in making rough flat castings.

overhang.—The extension at the parting line of the cope half of a core print beyond that of the drag in order to provide clearance for the closing of the mold.

pad.—Shallow projection on a casting distinguished from a boss or lug by shape and size.

parted pattern.—Pattern made in two or more parts.

parting.—Joint or plane of separation in a mold made of two or more sections.

parting compound.—Fine bondless commercial preparation dusted over the joint of a mold to prevent the contacting surfaces from adhering.

parting line.—That line about a pattern where the pattern or its mold separates.

parting sand.—Fine bondless sand. See Parting compound.

pattern.—Form modeled in any material from which a mold may be made; it is the basis of foundry practice.

pattern board.—See Molding board.

pattern checking.—Verifying the dimensions of a pattern with those of the drawing as well as its moldability.

pattern layout.—Full-size drawing of a pattern showing its arrangement and structural features.

pattern letters and figures.—Affixed to a pattern as a means of keeping a record of the pattern and for the identification of the casting.

pattern members.—The component parts that go toward making up a pattern.

pattern record card.—A filing card giving a description, location in storage, and the movement of a pattern.

patternmaking.—Deals with the modeling in wood, metal, or other materials of objects that are to be cast in metal.

permeability.—Refers to the venting qualities or to the rate at which gases can pass through the sand.

"picking up a line."—Method of transferring an irregular line from the layout to the material by placing the heads of small flat-head brads in a row in the line to be transferred and pressing the material down upon them.

pinch dog.—Staple-shaped steel bar with the angle of the sharpened points on the inside of the prongs, used for the temporary clamping together of wood.

pig iron.—Cast iron as it comes from the blast furnace in which it was produced from iron ore.

plaster pattern.—A pattern made from plaster of Paris.

plugged impressions.—Impressions formed by inserting a plug of required shape through a pattern into the sand.

porosity.—Full of pores or holes like a sponge.

ramming.—Packing sand around a pattern in making a mold.

rapping.—Jarring a pattern to loosen it from the sand preparatory to drawing it out.

rapping bar.—Iron bar used as an aid in rapping a pattern.

rapping plate.—Metal plate attached to a pattern for the insertion of a rapping bar.

rechucking.—Reversing of a piece of work upon a face plate so that the surface that was against the face plate may be turned to shape.

refractor.—Having heat-resisting qualities.

rib.—A stiffening member.

riddled sand.—Sand that has been passed through a riddle or screen.

riser.—An opening made from the mold cavity to the top of the mold in which the metal will rise during the pouring operation and which may later act as a feeder for the prevention of porosity in the casting due to shrinkage.

rolling over.—Reversing the position of a mold.

runner.—Channel through which the molten metal is conducted to the gate or gates.

sectional core.—A core made in two parts and pasted or wired together.

segmental construction.—See Laminated construction.

setup.—Any arrangement of material or work for further processing or use.

shrinkage.—Arrangement of the molecules of metal as it passes from a liquid to a solid state.

shrinkage rule.—See Contraction rule.

sizing.—Primary coating of very thin glue given to end grain wood to seal the pores.

skeleton pattern.—A framework representing the interior and exterior form and the metal thickness of the required casting.

slab core.—Plain flat core.

slicker.—One of a number of tools used for mending and smoothing the surface of a mold.

slip jacket.—Wood or metal frame used to slip over a snap flask made mold to reinforce it while it is being poured.

snap flask.—Flask used for bench molding and distinguished from the ordinary type of flask by being divided diagonally and the two parts hinged and latched together so that the flask may be removed from the mold.

spider.—An open web whose members radiate from the center like the spokes of a wheel.

spline.—A thin strip inserted into a groove to strengthen the work or to reinforce a joint.

spot facing.—Truing a circular bearing surface about a hole. It does not affect a pattern.

spot gluing.—Securing two pieces of material together temporarily with a spot of glue.

sprue.—An opening that conducts the metal from the top of the mold to the gate or gates. The term *sprue* is also applied to the metal which fills the pouring channels and is found attached to the casting.

sprue plug.—Wood or metal tapered pin used to form a sprue opening.

standard pattern.—A pattern in daily use or used at frequent intervals and therefore of first quality workmanship and material.

standard pattern colors.—Colors to be used for the marking of patterns as recommended by the American Foundrymen's Association and registered as Commercial Standard C S 19–30, Washington, D.C.

stave construction.—Attaching staves to polygon-shaped heads in the building of cylindrical bodies and also used for semicircular cavities.

"stepped up."—So called because the material, when fastened together, resembles steps.

stock cores.—Cores of standard diameters usually made on a core machine and kept in stock. They are cut to the required lengths.

stopping off.—Process of filling up with sand a part of a mold to eliminate that part not wanted as a part of the casting.

stopping-off core.—A core used in stopping off an unwanted part of a mold.

stopping-off piece.—Specially prepared piece or section of a pattern used for stopping off an unwanted part of a mold or core box.

straightedge.—Relatively long piece of material having one or both edges a true plane.

strickle or strike.—Piece of material having a straight or curved edge used for removing excess sand from a flask or pattern.

superimposed core.—See Cap core.

suspended core.—A core having the core seat so formed that it may be suspended above the mold.

swab.—Small bundle of bound hemp used in dampening the sand lying along the edge of a pattern preparatory to the drawing operation.

tally mark.—A symbol or combination of same indicating the correct location of a loose piece of a pattern or core box.

tempering sand.—Dampening and mixing sand to produce a uniform distribution of moisture.

templet.—Thin piece of material with the edge corresponding to a specific contour and used as a guide or for checking purposes.

temporary pattern.—A pattern used to produce one or two castings and therefore made as cheaply as the case will permit.

tie piece.—A barlike connecting member not necessarily shown on the drawing but built into the pattern and made a part of the casting in order to equalize the contraction occurring between widely separated members.

tongue.—See Spline.

tool clearance.—An open space provided in a casting for a cutting tool to enter in finishing an enclosed surface.

trowel.—Tool used in slicking, patching, and finishing a mold.

venting.—The perforating with a venting needle of the sand over and around a mold cavity to assist in the escape of the gases.

venting needle.—Thin stiff wire or rod used in venting the sand.

warping.—Distortion of a board through the absorption or expulsion of moisture. Also applied to a casting drawn out of shape by uneven cooling of the metal.

water brush.—Combined rubber bulb and brush. See Swab.

web.—A plate or thin member lying between heavier members.

winding strips.—Parallel straightedges used in testing large working faces or surfaces.

working edge.—Edge surface of a piece of material that has been planed straight and square with the working face.

working face.—Surface of a piece of material that has been planed true and that is to be used as a basis for the dressing of all other surfaces.

working model.—Rough model of a casting which is made so that the molding possibilities and the structural features of the pattern may be more clearly visualized.

VISUAL AIDS

The following list of 16mm sound motion pictures can be used advantageously with the material in this book.

These films were produced by the U. S. Office of Education and are distributed through Castle Films, Inc., 30 Rockefeller Center, New York City. These films can also be secured in many cases from your local film library or local film distributor. Many large universities maintaining extension film libraries will have this series available.

The running time (min) is given with each title.

Each of these motion pictures has a coordinated silent film strip and an instructor's manual.

FUNDAMENTALS OF PATTERNMAKING

Making a One-piece Flat Pattern (22 min)
Making a Pattern with a Vertical Core (14 min)
Making a Pattern with a Horizontal Core (14 min)
Making a Pattern with a Tail Print (19 min)
Making a Core Box for a Tail Print (18 min)
Making a Segmented Pattern (22 min)
Making a Pattern for a Three-part Mold (20 min)
Making a Pattern for a Flanged Pipe Elbow (18 min)
Making a Match Board Pattern (21 min)
Making a Core Box for a Vertical Core (19 min)
Making a Core Box for a Flanged Pipe Elbow (21 min)

PROBLEMS IN PATTERNMAKING

Making a Pattern Using a Green and a Dry Sand Core (14 min)
Making a Pattern Requiring a Cover Core (14 min)
Making a Pattern Requiring Box Construction (17 min)
Making a Core Box for a Machine Base (13 min)

Making a Pattern Requiring Segmental Construction (13 min)
Redesigning a Pattern for Production Purposes (11 min)
Designing a Pattern for a Water-cooled Motor Block (15 min)
Designing Core Boxes for a Water-cooled Motor Block (12 min)
Making a Master Pattern and Core Boxes for a Water-cooled Motor Block (15 min)
Making a Pattern for a Machine Molded Steel Globe and Angle Valve (4 min)

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